EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON SELECTED SOIL CHEMICAL PROPERTIES AND MAIZE (*Zea mays* L.) YIELD AT DEMBIA WOREDA, NORTH GONDAR, ETHIOPIA

M.Sc.Thesis

Tadesse Demissie

May 2017
Gondar, Ethiopia

EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON SELECTED SOIL CHEMICAL PROPERTIES AND MAIZE (*Zea mays* L.) YIELD AT DEMBIA WEREDA, NORTH GONDAR, ETHIOPIA

By

Tadesse Demissie

A Thesis Submitted to the Department of Natural Resource Management, College of Agriculture and Rural Transformation, University of Gondar In Partial Fulfillment of the Requirements for the Degree of Master of Science in Soil Science

Major Advisor: Hailu Kendie (PhD)

Co-advisor: Kehali Jembere (PhD Candidate)

May 2017
Gondar, Ethiopia

THESIS APPROVAL SHEET

UNIVERSITY OF GONDAR
POSTGRADUATE DIRECTORATE

The M.Sc. Thesis by **Tadesse Demissie** entitled as "**Effect of organic and inorganic fertilizers on selected soil chemical properties and maize (*Zea mays* L.) yield at Dembia Wereda, North Gondar, Ethiopia**" submitted to postgraduate directorate for open defense as a fulfillment of Master's degree in Soil science, Department of **Natural resource management**, College of Agriculture and Rural Transformation, University of Gondar, Ethiopia.

Submitted by: ___________________________ _________ _______

Name of Student Signature Date

Approved by:

1. ___________________________________ _________ _______
   Name of Major Advisor Signature Date
2. ___________________________________ _________ _______
   Name of Co-Advisor Signature Date
3. ___________________________________ _________ _______
   Name of Chairman, DPGC Signature Date
4. ___________________________________ _________ _______
   Name of Coordinator, CART PGC Signature Date

UNIVERSITY OF GONDAR
POSTGRADUATE DIRECTORATE

As thesis research advisors, we hereby certify that we have read and evaluated this thesis prepared under our guidance by [Tadesse Demissie Endeshaw] entitled "**Effect of organic and inorganic fertilizers on selected soil chemical properties and maize (*Zea mays* L.) yield at Dembia Wereda, North Gondar, Ethiopia**". We recommend that it be submitted as fulfilling the thesis requirement

Hailu Kendie (PhD) ………………………………. ………………………..
Major Advisor Signiture Date

Kehali Jembre ………………………………. ………………………..
Co-Advisor Signiture Date

As members of the Board of Examiners of the M.Sc. thesis open defense examination, we certify that we have read and evaluated the thesis prepared by **Tadesse Demissie Endshow** and examined the candidate. We recommend that the thesis be accepted as fulfilling the thesis requirements for the degree of Master of Science in **Soil Science**

……………………………… ………………………… …………………..
Chairperson Signature Date

……………………………… ………………………… ………………….
Internal examiner Signature Date

……………………………… ………………………… ………………….
External examiner Signature Date

DEDICATION

This thesis manuscript is dedicated to my father **Demissie Endshow,** my Mother **Awagie Feleke ,** my sisters **Belaynesh Demissie and yetmegn Demissie** who put strong effort on my education and careers but both could not destine to see the fruits of their efforts.

DECLARATION

By my signature below, I declare that this thesis is my own work. I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this thesis. All scholarly matter that is included in the thesis has been given recognition through citation. Every serious effort has been made to avoid any plagiarism in the preparation of this thesis.

This thesis is submitted in fulfillment of the requirement for M.Sc.degree from the Postgraduate Directorate at University of Gondar. I solemnly declare that this thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

The thesis is deposited in the University of Gondar Library and is made available to borrowers under the rules of the library. Brief quotations from this thesis may be used without special mission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from, or reproduction of, this thesis in whole or in chapter may be granted by the Head of the Department of Natural Resource Management, UoG, when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, however, permission must be obtained from the author of the thesis.

Name: Tadesse Demissie Signature: ______________________

Date of Submission: ………………………..

Department: Natural Resource Management

AUTHOR'S BIOGRAPHY

The author Tadesse Demissie was born on 6^{th} November 1966 in the Amhara National Regional State, South Gondar Administrative Zone, in a recently named **Guna -Kimer dengay***Woreda*. He ~~then~~ attended his primary school education at Kimer dengay elementary school and in the subsequent years, he enrolled at Atse Tewodros secondary school in Debre-tabor town where he sat for the Ethiopian Schools Leaving Certificate Examination in 1982. After passing the examination, he joined in the then called Jimma Junior College of Agriculture, and completed with diploma in general agriculture in 1984.

After graduation, Tadesse had been employed by ministry of agriculture and serve for more than 15 years as a development agent, *Woreda* extension coordinator and other job titles. In June 2002, he joined Mekelle University, to pursue his undergraduate program in the College of dry land Agriculture, Department of land resource management and environmental protection. In 2005, he obtained his B.Sc degree in Land Resource Management and Environmental Protection. After graduation, Tadesse has been employed by Gondar soil laboratory and served as soil surveyor from 2006 to 2012, and as center manager from 2013 to date. In 2015, the author joined University of Gondar to pursue his postgraduate study in soil science.

ACKNOWLEDGEMENT

During my thesis work many people were involved to help me in many aspects to bring in to fruitful results. I am highly grateful to my major advisor Dr Hailu Kendie, Soil Directorate Director of Gondar Agricultural Research Center, for his direct support from the beginning of proposal, consistent guidance, constructive criticisms and suggestions on the manuscript that enable me to shape up this thesis in its final form. It is my great pleasure to extend my appreciation to my co-advisor Mr.Kehali Jembere,for providing me valuable ideas, encouragement to do more and for reviewing the thesis manuscript.

I am grateful to Amhara Region Agricultural Research Institute and Gondar Agricultural Research Center for granting me fund for my graduate research study. Lots of thanks go to all staff members of Gondar soil laboratory for their valuable support during soil laboratory analysis. My greatest acknowledgment goes to Mr Yalew Tizazu, for providing me some technical assistance in the research data collection.

Finally, I would like to say tanks for God for the success of my life and also thanks my family to support for successful completion and make it 2017 EC the success of the year for us.

ABBREVATIONS AND ACRONOMS

ANRS	Amhara National Regional State
ANOVA	Analysis of Variance
Bd	Bulk density
CSA	Central Statistics Authority
ESSS	Ethiopian society of soil science
GDP	Gross Domestic Product
GNE	Grain number per ear
GNR	Grain number per row
GWR	Grain weight per ear
ISFM	Integrated soil fertility management
NGZF	North Gondar Zone Finance
SAS	Statistical Analysis System
TSP	Triple super phosphate
IPNI	International Plant nutrition institute

TABLE OF CONTENTS

TABLE OF CONTENT (*Continued*)

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDIX TABLES

Appendix Table **Page**

EFFECT OF ORGANIC AND INORGANIC FERTILIZERS ON SELECTED SOIL CHEMICAL PROPERTIES AND MAIZE (*Zea mays* L.) YIELD AT DEMBIA *WOREDA*, NORTH GONDAR, ETHIOPIA

ABSTRACT

The economy of Ethiopia is based on agriculture; however Ethiopia's agriculture is plagued by periodic drought, soil degradation, caused by overgrazing, deforestation, and high population density. Soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and organic matter (OM) content and low soil fertility is one of the critical issues to sustain agricultural production and productivity in the country. The integrated use of organic nutrient sources with inorganic fertilizer was shown to increase the potential of organic fertilizer and to improve the efficiency of inorganic fertilizers, The experiment was conducted in rained fed agriculture for 2016/17 cropping season in Dembia Woreda to explore the effects of integrated application of organic and inorganic fertilizers on the major soil chemical properties and on the productivity of maize. The treatments used were factorial combination of three rates of compost (0, 5 and 10 ton) and five rates of blended fertilizers (0, 100kg, 200kg, 200+kg and 200kg DAP). Improved maize variety of BH-540, widely used in the study area, was used as a test crop. The field experiment was laid out in randomized complete block design (RCBD) with three replications and the laboratory analysis including before planting and after harvesting soil sample, compost nutrient content analysis was done in appropriate procedure at Gondar Soil testing laboratory. There was statistical difference between the sole use of organic and inorganic fertilizers as well as integrated application which shows in (table 4, 5 and 6), (200kgblended fertilizer which is recommended for exponential site(T3)) productivity (8.81 ton/ha) was lower than the integration application of half blended and 10 ton /ha compost (9.13 ton/ha) and almost equal production to 5 ton compost with 100 kg blended fertilizer application (T7) increased OM, N, P and K nutrients content (4.05%, 0.16%, 26.43 mg kg^{-1}, 1.17 coml./kg) respectively. From the result of the experiment, and MRR, application of 200 kg DAP fertilizer with 200 kg urea was recommended. However, application of 5 ton compost ha^{-1} + 100 kg blended ha^{-1} with split application of 200 kg ha^{-1} urea could also be recommended if organic materials for compost preparation are scarce and when the prime objective is to get higher maize yield. It is also necessary develop further research such as nutrient omission trial to verify nutrient–nutrient interaction before recommendation of blended fertilizers specially to recommend the micro nutrient such as boron and others, soil test based is optional because micro nutrients are not only essential but also toxic if there are excess.

Keywords: blended, organic, integrated, soil fertility, grain yield

1. INTRODUCTION

The economy of Ethiopia is based on agriculture, which accounts for 46.3% of gross domestic product (GDP), 60% of export earnings, and 80% of total employment. Agricultural production is overwhelmingly of a subsistence nature, and a large part of commodity exports are provided by the small agricultural cash-crop sector (World Fact book, 2016).

Ethiopia's agriculture is plagued by periodic drought, soil degradation, caused by overgrazing, deforestation, and high population density. Yet, agriculture is the country's most promising resource. A potential exists for self-sufficiency in grains and for export development in livestock, grains, vegetables, and fruits. Many other economic activities depend on agriculture, including marketing, processing, and export of agricultural products (World Fact book, 2016).

People are dependent on soil, and, conversely, good soils are dependent on people and the use they make of land. Soils are the natural bodies in which plants grow. They provide the starting point for successful agriculture (Brady and Weil, 2002). Throughout human history, our relationship with the soil has affected our ability to cultivate crops and influenced the success of civilizations. This relationship between humans, the earth, and food sources affirms soil as the foundation of agriculture (Parikh, 2012).

Soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and organic matter (OM) content and low soil fertility is one of the critical issues to sustain agricultural production and productivity in the country (Damene,2003). Anthropogenic factors such as inappropriate land use systems, nutrient mining and inadequate supply of nutrients have aggravated the situation (Wakene *et al.,* 2007).

When soil does not supply sufficient nutrients for normal plant development and optimum productivity, application of supplemental nutrients is required. However, the proper application rates of plant nutrients are determined by knowledge about the nutrient requirement of the crop and the nutrient supplying power of the soil which is seldom practiced in Ethiopia.

Chemical fertilizers play a major role in supplementing nutrients for crops, although applications of chemical fertilizers only are not economical for the farmers. The sole use of chemical fertilizers is causing deterioration in soil physical, chemical and biological properties (Zarina *et al*., 2010). The integrated use of organic nutrient sources with inorganic fertilizer was shown to increase the potential of organic fertilizer and to improve the efficiency of inorganic fertilizers, (Heluf, 2002).

Farmers of Ethiopian highlands have been applying chemical fertilizers like di-ammonium phosphate (DAP) and urea to increase crop yields at a blanket rate rather than relating it to site-specific and crop-nutrient requirements (Tasnee and Yost, 2003).Current fertilizer recommendations of the country have to consider adoption of site-specific balanced and integrated nutrient management involving major, secondary and micro nutrients, organic manures and amendments by creating awareness amongst farmers on benefits of balanced fertilization,(ATA,2015).

Soil OM is the main source of N (about 97%) for plant growth (Allison, 1973). More than 95% of S, up to 50% of P and micronutrients held in organic forms (Brady and Weil, 2002). Wakene *et al*. (2007) reported that OMs influence nutrient availability by controlling the net mineralization-immobilization patterns and they interact with soil minerals in complexing P fixing cations there by reducing P sorption capacity.

Compost (decomposed OM) is an organic fertilizer that can be made on the farm at very low cost (cost-effective biological treatment method) (Tiquia and Tam 2002; Madeleine, 2005). Its amendment to soil is often viewed as a way to improve soil fertility and increase in the amounts of soil organic carbon (OC) and of other major nutrients such as N, S and P (Carine *et al.,* 2006). The values given in the references for the desirable N and S contents at the outset of composting vary between 1.5% to 2.0% and 0.45% to 0.70% respectively, as computed on dry weight basis (James *et al.,* 1982; Beyer, 2003).

Previous studies showed that the combination of compost with chemical fertilizers further enhanced the biomass and grain yield of crops. Hence, integrated application of locally available organic materials like compost along with inorganic fertilizers is economically feasible and environmentally safe for sustainable crop production (Rajeshwari, 2005).

The use of farmyard manure for domestic energy consumption increases from time to time instead of using it as a soil amendment. Thus, research on the effect of integrated application of organic and inorganic fertilizers for increasing grain yield and improving soil properties is an important issue for Ethiopian highlands.

However, integrated application of organic and inorganic fertilizer is not practiced in soils of Dembia *Woreda* (the study area) where infertile and nutrient depleted soils are more common. Traditional farm management practices such as continuous cropping and crop residue removal might be responsible for a steady depletion of the fertility status of the soils (Gondar soil testing lab report, 2013).

Among cereals, Maize (Zea mays L.) is the most important cereal crop next to wheat and rice in the world (Muhammed et al., 2004). It is grown over an area of 130 million ha with an annual production of 506 million t with a productivity of 3890 kg ha^{-1}. Maize is called "King of Cereals" because of its productive potential compared to any other cereal crop. Being an exhaustive crop, it has very high nutrient requirement and its productivity is closely depends on nutrient management system (Rajeshwari, 2005).

It is one of the most important staple food crops in Ethiopia. At the national level 2,110,209 ha of land is covered by maize and over 72,349,551 quintals are produced with a yield of 34.28 quintals ha^{-1} in 2007 EC (CSA, 2015). Although it has better productivity 37qunta1 per hectare, maize covers about 24.8% of the crop land and 39.71% of the total crop production of the study area (NGZF, 2014).

Moreover, farmers of the study area are not well acquainted in preparing and applying organic fertilizers (including compost) and the knowledge concerning integrated use of organic fertilizers with chemical fertilizers is scanty. Similarly, fertilizer rate recommendations for the integrated application of organic and inorganic fertilizers are not available in the study area. Therefore, conducting research on the integrated application of organic and mineral fertilizers and evaluating their combined effect on soil property changes and crop productivity is crucial. Therefore, this study was initiated to address the following objectives:

General objective

- To evaluate the effects of integrated application of organic and inorganic fertilizers on soil fertility and maize crop productivity.

Specific objectives

- To evaluate the effect of compost on soil properties and maize crop productivity.
- To evaluate the effect in organic fertilizer on soil properties and maize crop productivity.
- To evaluate the interaction effect of compost and inorganic fertilizers on soil properties and maize crop productivity.

2. LITERATURE REVIEW

Agriculture in Ethiopia has long been a priority and focus of national policy, such as Agricultural Development Led Industrialization (ADLI), and various large-scale programs, such as the Plan for Accelerated and Sustained Development to End Poverty (PASDEP). The sector employs about 80% of the population, generates over 46% of gross domestic product (GDP) and 60% of export earnings, and plays a significant role in improving food security in the near- to mid-term. It is no surprise that it is widely agreed that Ethiopia has both the potential and the need to achieve better crop yields, particularly for food security (International Food Policy Research Institute, 2013).

The perception of Ethiopia projected in the media is often one of chronic poverty and hunger, but this bleak assessment does not accurately reflect most of the country today. Ethiopia encompasses a wide variety of agro ecologies and peoples. Its agriculture sector, economy, and food security status are equally complex. In fact, since 2001 the per capita income in certain rural areas has risen by more than 50 percent, and crop yields and availability have also increased (IFRPI, 2013).

2.1. Maize (*Zea mays* L.) Production and Yield in Ethiopia

Maize is not indigenous to Ethiopia and is believed to have been introduced into the country in the 1600s and 1700s. It is widely grown in the country in various agro-ecological zones. It grows in altitudes ranging from 500-2400 m above sea level (masl). It is an important crop in terms of acreage, production and yield (Friew and Girma, 2001).

Sub-humid agro-ecosystem of western Ethiopia is the major maize producing belt in the country where the highest maize grain yield (11 ton ha^{-1}) was record under the farmers' field by using improved maize technologies for the first time in the history of Ethiopian agriculture in 1993 when sasakawa global (SG) 2000 started to operate in the country (Wakene *et al.,* 2007).

Maize continues to be a significant contributor to the economic and social development of Ethiopia. Although it is the staple cereal crop, critical to 8 million smallholder livelihoods and plays a central role in the country's food security, it has low productivity with the highest current yield from available inputs at2.2 ton ha^{-1} in 2008/09 from a potential yield of about 4.7 ton ha^{-1} (Shahidur *et al.,* 2010).

Maize is grown primarily in the Amhara, Oromia and SNNP regions of Ethiopia. While there have been, significant gains made in maize production over the past decade, there is still a significant opportunity to further increase productivity. Maize is Ethiopia's most important cereal in terms of production, with 6 million tons produced in 2012 by 9 million farmers across 2 million hectares of land. From 2001 to 2011, maize production increased by 50%, due to increases in both per hectare yields (+25%) and area under cultivation (+20%). Estimates indicate that the current maize yield could be doubled if farmers adopt higher quality inputs and proven agronomy best practices (ATA, 2013).

2.2. The Requirements, Productivity and Characteristics of Maize

Maize is the most important cereal crop next to wheat and rice in the world. In the world, it is grown over an area of 130 million ha with an annual production of 506 million t with a productivity of 3890 kg ha^{-1}. Maize is called "King of Cereals" because of its productive potential compared to any other cereal crop. Being an exhaustive crop, it has very high nutrient requirement and its productivity is closely depending on nutrient management system (Rajeshwari, 2005).

The factors determining the growth and final yield of maize *(Zea mays L.)* are climate, soil, and fertilizer and crop management. Maize has adapted a wide range of environmental conditions. It is the most widely distributed cereals in the world (Onwueme and Sinha, 1991). It is a sun-loving crop and requires a long, hot growing season with plenty of sunshine. Maize is grown from below sea level to altitudes of 3000 m. An average summer temperature of 20^0 - 21^0 C seems to be the most favorable for maximum yield of maize. The annual precipitation where corn is grown ranges from 250 mm to more than 5000 mm in the tropics (Edward, 1992).

Maize has high production potential when compared to any other cereal crop. The productivity of maize is largely dependent on its nutrient management. It is well known that maize is a heavy feeder of nutrients (Basavaraju, 2007). It is one of the most important cereal crops of the world extensively grown in irrigated and rain fed areas (Irshad *et al*., 2002). It is multipurpose crop and provides food for human beings, fodder for livestock and feed for poultry. It has great nutritional value as it contains about 66.70% starch, 10% protein, 4.8% oil, 8.5% fiber, 3% sugar and 7% ash (Chaudhry, 1983). Maize is high yielding, easy to process, ready digested and cheaper than other cereals. Every part of the maize plant has economic value; the grain, leaves, stack, tassel and cob can all be used to produce a large variety of food and non-food products (IITA, 2007).

2.3. Soil Fertility Depletion in the Ethiopian Highlands

Soil degradation is widely recognized as a global problem associated with desertification (Gisladottir and Stocking, 2005). In Sub-Saharan Africa, it is also associated with soil fertility depletion (mainly the N, P and OC) which is a major threat to food security (Sanchez and Jama, 2002; Bationo *et al.*, 2004). This problem is exacerbated by wind and water surface soil erosion (Zougmoré, 2003), poor rainfall distribution (Sivakumar and Wallace, 1991), restricted fallow periods to restore soil fertility (Floret and Pontanier, 2001) and low rates of fertilizer application (Camara and Heinemann, 2006). The region is also characterized by climatic conditions that accelerate the degradation of soil OM which, in turn, reduces the water holding capacity of the soils (Andren *et al*., 2007).

Soil productivity in Africa is declining as a result of soil nutrient and OM depletion, soil erosion and water scarcity. About 65% of the croplands in Africa have been affected by soil degradation during the last 40 years (Bationo *et al.*, 2007). In sub- Saharan Africa, croplands have a negative nutrient balance, with annual losses ranging from 15 to 71 kg^{-1} ha^{-1} of N, P and K mainly due to nutrient exports by harvest and losses by erosion, combined with low inputs (Stoorvogel *et al.,* 1993; Henao and Baanante, 2006).Poor soil management and the fragile nature of tropical soils generally account for heavy nutrient losses through soil erosion and nutrient leaching in soils (Hossner and Juo, 1999).

Hurni (1993) reported that at the national level, soil loss on Ethiopian cultivated fields is estimated 42 t ha^{-1} yr^{-1}. The causes of land degradation in Ethiopia are cultivation on steep and fragile soils with inadequate investments in soil conservation or vegetation cover, erratic and erosive rainfall patterns, declining use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation and overgrazing (Hurni, 1988; Belay, 2003). The low level of chemical fertilizer use, decline in soil OM, and insufficient attention to crop nutrient studies contribute the most to the loss of soil fertility in the country (Kumwenda *et al.,* 1996).

Ethiopia faces a wide set of soil fertility issues or soil fertility challenges that require approaches that go beyond the application of chemical fertilizers. Core constraints in the country include topsoil erosion (affected soils covering over 40% of the country), significantly depleted OM due to widespread use of biomass as fuel, depleted macro and micro-nutrients, depletion of soil physical properties and soil salinity (ESSS,2006).

Low productivity in Ethiopia's agriculture sector is caused in part by a range of factors related to poor soil conditions: Severe land degradation; Nutrient depletion; Complete removal of crop residue from the fields; Fragmented or not application of Integrated Soil Fertility Management (ISFM) technology Little or no manure application; Imbalanced inorganic fertilizer use; and Lack of comprehensive soil fertility information. A number of soil-related studies and programs have been carried out in the past to reverse the impacts of such constraints. However, acquiring updated and accurate soil-related information has remained a challenge. Consequently, further scientific analysis has been hindered that could provide strategic information for policy makers, researchers, extension workers and smallholder farmers (EJNR, 2001).

As such, soil health and fertility were prioritized as key components of the Agricultural Transformation Agenda, with potential to increase smallholder farmers' productivity. The Ministry of Agriculture (MoA) and the ATA thus developed the Soil Health and Fertility Roadmap and the Soil Health Strategy in 2011 and 2012 respectively. Both aim to address key soil fertility bottlenecks and transform the agriculture sector, by incorporating soil health, increasing yield and ultimately doubling smallholder farmers' incomes.

The systematic organization of soil-related information has resulted in challenging the use of DAP as a blanket recommendation. A detailed woreda-level soil fertility status atlas was therefore paramount to tailoring fertilizer recommendations to specific soil fertility conditions. Additional scrutiny of land features (vegetation, climactic factors, erosion risk, etc.), physical and chemical properties of soil is critical for acquiring knowledge on soil health and fertility (ATA, 2014).

2.4. Effects of Compost on Improving Soil Physicochemical Properties

In many experiments, it was shown that compost use can substantially improve soil physical, chemical and biological properties, which are often important factors in determining its fertility status. The improvement of these soil properties results often in indirect benefits such as reduced erosion, ease of cultivation, increased fertilizer efficiency due to a higher CEC or a reduced disease incidence. Compost as OM has many essential roles to play; in maintaining soil fertility, macro and micro nutrients for plant growth and alkaline substances which counteract soil acidification. However, compost use tends to show its full potential only after prolonged use. Many new research projects, which assess the effects of compost use, are long-term, running for 5 - 10 years (Johannes, 2000).

In degraded soils – i.e. those with low soil fertility and minimal organic matter – the effect that mineral fertilizers have on crop yields remains low. This is because these soils have a low capacity to bind dissolved nutrients (from mineral fertilizers,) into the soil and make them available to plants. As a consequence, a large portion of the nutrients is washed out in the groundwater and is lost (Kotschi, 2013).

Organic inputs, including compost, animal manure, crop residues and green manure, are a good method of enhancing both soil physical, chemical and biological properties and crop performance (Jama *et al.*, 2000). Organic inputs contribute to improving soil structure/aggregation and decrease soil bulk density, and thus increase the percentage of pore space (Sylvia *et al.*, 1999). As consequence, soil water infiltration and water holding capacity increase (Weber *et al.*, 2007) but the strength with which water is held may also increase. It also increases the capacity of the soil to buffer changes in pH and CEC, and serves as a reservoir of nutrient such as N, S, P and many minor elements (Schlecht *et al.*, 2006). Organic inputs are also source of energy and slowly available C to support soil organisms' activity which are the primary agent for decomposition in the soil and increase enzymatic activity (Marinari *et al.*, 2000).

In the field research conducted at the Iowa State University Agronomy and Agricultural Engineering Research Farm by Singer *et al.* (2004), compost plots had 13% higher OM concentrations compared with no compost plots after both two and three compost applications. Compost application increased soil K by 26, 38 and 55% compared with no compost in the corn, soy bean and wheat phases, respectively. Averaged, across crops and tillage, compost application increased soil P to 164 mg kg^{-1} compared with 55 mg kg^{-1} without compost (Singer *et al.,* 2004).

Soil OM encourages granulation, increases CEC and is responsible for up to 90% adsorbing power of the soils. Cations such as $Ca^{2+,}$ Mg^{2+} and K^+ are produced during decomposition (Brady and Weil, 2005). In general, it may be concluded that compost application increased soil pH, electrical conductivity (EC), OM, $Ca^{2+,}$ Mg^{2+}, K^+ and P while C: N ratio was narrowed in acidic soil. Hence, there was a general increase in nutrient supplying capacity of soils and compost application was a good strategy for enhancing fertility status of depleted soils (Sarwar *et al*., 2010).

The optimal C: N ratio for effective composting ranges from 25 - 30:1, although initial C: N ratios from 20:1 to 40:1consistently produce good results. Frank *et al*. (2006) revealed that if the C: N ratio is much above 30:1, microorganisms will immobilize soil N. None of the heavy metals toxicity problems are likely to occur with compost that has been made from farm manures or crop residues or with the commercially available composts of today.

A decay or mineralization series is commonly used to estimate the rate of N availability from stable organic N. A decay series of 35, 12, and 5% is used to estimate the rate of decomposition of organic N in liquid (<18% dry matter) dairy manures in New York. This sequence of numbers means that 35% of the organic N is mineralized and potentially taken up by the growing crop during the year the manure was applied, 12% of the initial organic N application is mineralized and taken up during the second year, and 5% is mineralized and taken up in the third year (Quirine *et al*., 2003).

Johannes, (2000) stated that about 10-15% of N and 30 – 40 % P_2O_5 are available in the first year while approximately 40% and 100% after four years respectively. Typical bio-waste compost contains approximately 1.4% of N on a dry matter basis although the nutrient content varies from different reports. Results showed that in the supply of approximately 140 kg total N if 10 t dry matter of compost is applied ha^{-1} as is often practiced by growers. However, only 10 - 15% of the total N is plant available during the first year, while the remainder is tied up in organic compounds and will be partly released over time (approximately 40% of total N in four years). This means that between 42 and 64 kg N ha^{-1} will be available for plant uptake during the first year after compost application (30 t dry matters).

After continued compost application, total and available P and K concentration in the soil are increased. In contrast to N, the P, K and Mg show in principle higher plant availability. Short-term use of compost is targeting to supply nutrients and enhanced microbial activity while longer term benefits tend to maximize the build-up of C-pools, nutrient pools and improvement in soil physical properties (Federal Ministry of Agriculture, 2003). Approximately 20% of P in compost is immediately available for plant uptake while the remainder is more strongly bound and will become available later (Johannes, 2000).

Compared to other sources of organic materials, the poultry manure is relatively a cheap source of both macro nutrients (N, P, K, Ca, Mg, S) and micronutrients ((copper (Cu), iron (Fe), Mn, boron (B)) and can increase soil C and N content, soil porosity and enhance soil microbial activity. As poultry waste contains a high concentration of nutrients, addition of small quantity of it in an integrated nutrient management system could meet the shortage of FYM to some extent (Ghosh *et al.,* 2004).

Composting, which refers to the controlled decomposition of organic materials, has been used by farmers and gardeners since prehistoric times to recycle wastes and make them available for plant growth. In recent years, concern about reducing solid waste and producing food in an environmentally sound manner has led to a renewed interest in composting. All types of composting depend on the work of bacteria and fungi. These microbes digest OM and convert it into chemical forms that are usable by other microbes and plants (Nancy and Krasny, 1997). Composting is a biological process in which organic biodegradable wastes are converted into hygienic, humus rich product (compost) for use as a soil conditioner and an organic fertilizer (Popkin, 1995).

Compost analysis revealed that it had pH of 7.00, moisture content (14.73%), total N (1.74%), total P (0.49%) and K (2.45%). The total OC contents were 22.50% with OM (39.45%) and C: N ratio of 15.30 (Zarina*et al.,* 2010). However, a threshold moisture content of 40-60% is recommended for composting with a view to enhancing fertilizer value (Kihanda and Gichuru, 1999). So, composted OM can be used as a source of important nutrients for sustainable crop productivity. The composted organic wastes cannot only act as supplement to chemical fertilizers but may also improve the OM status and physicochemical properties of soil (Harmsen *et al*., 1994).

On the cost side, the "terms of trade" (a comparison between the costs of two items) in agriculture, and especially the ratio between mineral fertilizer and food products, have deteriorated steadily from one decade to the next. To compares the global fertilizer price with the World Bank's food price between 1970 and 2011, It shows that the world market price for mineral fertilizers has risen disproportionately when compared to the price of food – by over 250 % in 40 years. Other studies reveal similar trends. On the cost side, the "terms of trade" (a comparison between the costs of two items) in agriculture, and especially the ratio between mineral fertilizer and food products, have deteriorated steadily from one decade to the next (Kotschi, 2013). The price an individual farmer in a remote area has to pay for mineral fertilizer is a lot higher than the world market price because of transport, distribution and other transaction costs. The price that the same farmer gets for his or her farm produce, on the other hand, is far below the price in places with good market links. Moreover, fertilizer prices are prone to wide fluctuations, especially if they are imported and are priced in foreign currencies, as is the case in most developing countries.

2.5. Effects of Inorganic Fertilizer on Maize Yield and Yield Component

Mineral fertilizers continue to play an important role in increasing the food supply for future generations. It is estimated that around 50% of the annual global food harvest comes from the application of mineral N fertilizer alone Kotschi (2013). The judicious use of mineral fertilizers can play a critical role in preventing resource degradation that results from nutrient mining, and from the exploitation of fragile lands or the clearing of habitat-rich forests. Increased fertilizer use in Africa can create a win-win situation, by promoting more efficient crop production and reducing soil degradation. Mineral fertilizers should be at the core of strategies to restore soil fertility and raise crop productivity, although their use should be a part of integrated systems of nutrient management

Balanced nutrition is an essential component of nutrient management and plays a significant role in increasing crop production and its quality. For the major processes of plant development and yield formation, the presence of nutrients like N, P, K, S and Mg in balanced form is essential (Mahmood, 2004; Randhawa and Arora, 2000). plant will use essential elements only in proportion to each other, and the element that is in shortest supply—in proportion to the rest—will limit growth" (Liebig's law of the minimum, 1828**)**.

2.6. Effects organic fertilizer on maize yield and yield component

In the tropics, the maintenance and management of soil organic matter (SOM) are central to sustaining soil fertility on smallholder farms (Swift and Woomer 1993, Woomer et al. 1994). In low-input agricultural systems in the tropics, SOM helps retain mineral nutrients (N, S, micronutrients) in the soil and make them available to plants in small amounts over many years as SOM is mineralized. In addition, SOM increases soil flora and fauna (associated with soil aggregation, improved infiltration of water and reduced soil erosion), complexes toxic Al and manganese (Mn) ions (leading to better rooting), increases the buffering capacity on low-activity clay soils, and increases water holding capacity (Woomer et al. 1994). Current SOM inputs are insufficient to maintain organic matter levels in tropical agricultural soils. Continuous cropping, with its associated tillage practices, provokes an initial rapid decline in SOM, which then stabilizes at a low level (for example, see Woomer et al. 1994).

The conventional mechanisms for addressing losses of SOM in tropical, rain fed, low-input Systems are fallowing, rotations (especially involving legumes), and the addition of animal Manures, forms of intercropping (including intercropping with hedgerow legumes), reduced tillage. As pressure on arable land rises, cropping encroaches on areas previously used for grazing, and livestock production becomes more difficult. This problem is more common in the unimodal rainfall areas of southern Africa, where the long dry season makes zero grazing techniques difficult or impossible for smallholders, than in the bimodal rainfall areas of eastern Africa. Manure from cattle and other animals is very important for most farmers in Zimbabwe, less so in Zambia, but rarely available in Malawi (where animals are scarce). But even in the best areas, the supply (and, as important, the quality) of animal manure is inadequate to maintain soil fertility on its own. Where animals are few, farmers have turned to other sources of SOM. Leaf litter from trees can make significant contributions in areas close to woodlands, but as population grows, the deforestation associated with the demand for arable land, building material, and fuel works against this option. Although composted crop residues are used in wetter areas and where crop biomass production is relatively high, composts are rarely sufficient for more than a modest part of the cultivated area, and, like manures, their quality is often poor. These technologies require substantial labor from farmers (for examples from Zimbabwe, see Huchu and Sithole, 1994, and Carter 1993). The reality is that organic matter is rarely sufficient to maintain SOM, and in marginal areas where rainfall is low it is impossible to grow enough biomass to maintain SOM.

2.7. Effects of integrated application of organic and inorganic fertilizers on maize yield and yield component

Increased fertilizer use in Africa can create a win-win situation, by promoting more efficient crop production and reducing soil degradation. Mineral fertilizers should be at the core of strategies to restore soil fertility and raise crop productivity, although their use should be a part of integrated systems of nutrient management in which organic fertilizer sources are included. It also is important to mention that sources of organic manure are limited in most African countries. Even in Ethiopia, where livestock numbers are significant, manure is primarily used as a cooking fuel and rarely to improve the fertility of the soil (Kotschi, 2013). On low and medium soil fertility conditions, combined application of N fertilizers and manure led to increased productivity above fertilizer treatments alone, and this is most pronounced on degraded soils. Many studies in SSA have reported on the positive interaction between fertilizer and manure, with the benefits of manure increasing with decreasing soil fertility (Marena (2007).

(Barker dan Pilbeam, 2007) reported that, Long-term effects of continuous use of chemical fertilizers and manure on soil fertility and productivity of a maize were investigated in the ongoing long-term fertilizer experiment, during *Rabi* (2007–2008) and *Kharif* (2008) seasons at the research farm, after 16 cropping cycles, bulk density decreased in plots where farmyard manure (FYM) was applied, whereas pH decreased in all the treatments. The organic carbon content of the soil increased in all the treatments except 100% nitrogen (N). Cation exchange capacity (CEC) increased in all the treatments over the initial status of the soil. Available N showed buildup over the initial status in most of the treatments. Available phosphorus (P) declined from initial status in treatments where only N was applied alone or with FYM. There was reduction in available potassium (K) status in all the treatments except 100% NPK. Continuous addition of FYM with balanced application of inorganic fertilizers improved content of exchangeable calcium (Ca) and magnesium (Mg) over initial status compared to imbalanced application of fertilizers. Continuous use of imbalanced inorganic fertilizers resulted in lesser crop yields and nutrient uptake compared to that with the application of balanced dose of inorganic fertilizers with FYM.

Organic acids available in organic fertilizer can chelae toxic elements (metals) in soil so that soil condition is not harmful for crop growth. Organic acids are capable to decrease phosphate quantity which fixed by Fe and Al through chelating mechanisms so that P is become available for crops (Barker dan Pilbeam, 2007).

A urea combination with compost could have directly improving uptake of nutrients in maize and improving early maize root development. When compost was improving soil conditions (improving soil-water holding and N limiting factors) to maize, yield is improved. Compost is advantageous for it improves soil physical, biological, and chemical characteristics that consequently lead to better crop growth in the long term, as shown experiments done in Malawi and Sub-Saharan countries that use a small quantity of fertilizer and can benefit from the use of combined source of N (Bationo *et al*., 1998).

Besides to improving yields, application of compost improved soil fertility and increased the plant resistance to heavy metal toxicity thereby enhancing plant growth and dry matter yield of maize (Adejumo *et al.,* 2010). In several compost trials, combined compost and mineral N fertilization performed best. Due to low N efficiency, a positive yield effect of compost is achieved in the long term on soils, which are continuously managed with compost rather than after one or two applications (Federal Ministry of Agriculture, 2003).

Using paper sludge with low C: N ratios (13 to 15) and high N levels applications of those OM alone at rates of 30 to 90 t ha^{-1} produced high grain corn yields and N uptake in Canada.

In this study, the application of composted paper sludge with reduced rate of N fertilizer (120 kg ha^{-1}) led to high silage corn yields and N uptake in 2001 and 2002 similar to those found for complete rate of N fertilizer (160 kg ha^{-1}) for silage corn. The increased silage corn yields and N uptake in presence of composted paper sludge combined with reduced N fertilizer could be explained by the improvement of the soil aggregation and also by the additional nutrients in the composted paper sludge that could lead to better plant nutrition (Adrien *et al,* 2010).

Superiority of poultry manure was reported by (Chandrashekara *et al*. 2000) and (Saranappa 2002), showed 7.62% increase in seed yield of maize with the application of poultry manure. Mehta and Shaktawat (2002) reported that application of farm yard manure at 10 t ha^{-1} recorded higher grain yield and was economical.

Ferguson and Nienaber (1995) reported application of composted feedlot manure produced corn yields similar to inorganic fertilizer. Eghball and Power (1999) reported that compost application resulted in corn grain yield similar to the fertilizer treatment. Schlegel (1992) also found that grain yield of irrigated sorghum increased by 377 kg ha^{-1} for 2.24 t ha^{-1} of applied compost and was equivalent to the increase from 13.4 kg ha^{-1} of inorganic N fertilizer. Treatments combining composted manure and N fertilizer produced greater grain yields than either amendment alone. Sorghum yields were increased by 502, 1254, 1254, and 960 kg ha^{-1} in 1987-1990, respectively, with a combination treatment compared to either compost or N alone (Thomas, 2004).

The use of N fertilizer in combination with compost increased the grain yield significantly. For instance, interaction effects of N and compost on wheat grain yield in Iran indicated that the highest wheat grain yield was obtained in the combination of 160 kg N ha^{-1} and compost of 30 t ha^{-1} (Tayebeh *et al.,* 2010). The integrated use of FYM, compost and bone meal with low dose of NP fertilizers gave comparable maize grain when compared to the yield obtained under the recommended rate of NP fertilizers (110/20 kg ha^{-1}) in Bako area, Ethiopia (Wakene *et al.,* 2007).

Wakene *et al.* (2001) reported that the potentials of organic sources increase when used together with mineral fertilizers. Crop residues applied with recommended NP fertilizers produced 52% more sorghum grain on Inceptisols in Alemaya area than crop residues applied alone. The integrated use of various rates of farm yard manure and low rates of NP fertilizers are better than the application of either NP fertilizers or farm yard manure alone.

The concept of organic-inorganic combinations has been also demonstrated in central Kenya by (Kimani *et al*. 2001), where the combinations resulted in higher maize grain yields. In such demonstration, the increased maize yields above an unfertilized control were 60%, 50% and 40% for mineral fertilizer alone, fertilizer-manure combination, and manure alone, respectively, in a single season.

A complementary use of organic manure and mineral fertilizers has been recommended for sustenance of long-term cropping in the tropics. High and sustained crop yields can be obtained with judicious and balanced NPK fertilization combined with organic matter amendment (Makinde, 2007).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The field experiment was conducted in Dembia *Woreda* of North Gondar Zone, Amhara National Regional State (ANRS), about 60 km west of Gondar town. Dembia *Woreda* is bordered by Tana to the south, Alefa to the west, Gondar town to the north, Gondar zuria *Woreda* to the east.

The *Woreda* covers an estimated area of 1,261.96 square kilometers with a population density of about 16.85 persons per square kilometers, which is greater than the North Gondar Zone average of 8.68. The altitude of the *Woreda* ranges between 1858 and 2200 m. The land feature of the *Woreda* is characterized as 60% plains, 10% mountainous and 30% rugged that triggered soil erosion and nutrient depletion (Agriculture and Rural Development office of Dembia *Woreda*, 2015).

The average annual minimum, maximum and mean temperatures of the District were 11, 32 and 21.5^{o}C, respectively. The rainfall pattern is unimodal, stretching from May to September and the annual rainfall ranges between 995 and 1184 mm (Agriculture and Rural Development office of Dembia *Woreda*, 2015).

The trial site is situated in Gorgora kebele at 12^{0} 12' 28'' N and 37^{0} 01' 55'' E with an elevation of about 2000 m. Farming system in the experimental sites characterized by crop-livestock production where about 92% of the population is engaged in agriculture. Survey of the area revealed that, of the land under cultivation in the District, 64.53% was planted with cereals like teff, maize and finger millet, 2.81% with pulses like chick pea , 8.3% with oilseeds like *Noug*, 0.72% with perennial crops like coffee, 0.62% with root crops, 0.45% with vegetables, and 12.57% all other crops. However, maize, teff, chick pea and sorghum are the main food crops of the trial site. The estimated rural population size of the *Woreda* was 216,830; where 110,167 were male and 106,662 females while the urban population was 24,658 with male population of 11,598 and 13,892 females (Finance and Economic Development office of Dembia *Woreda*, 2014).

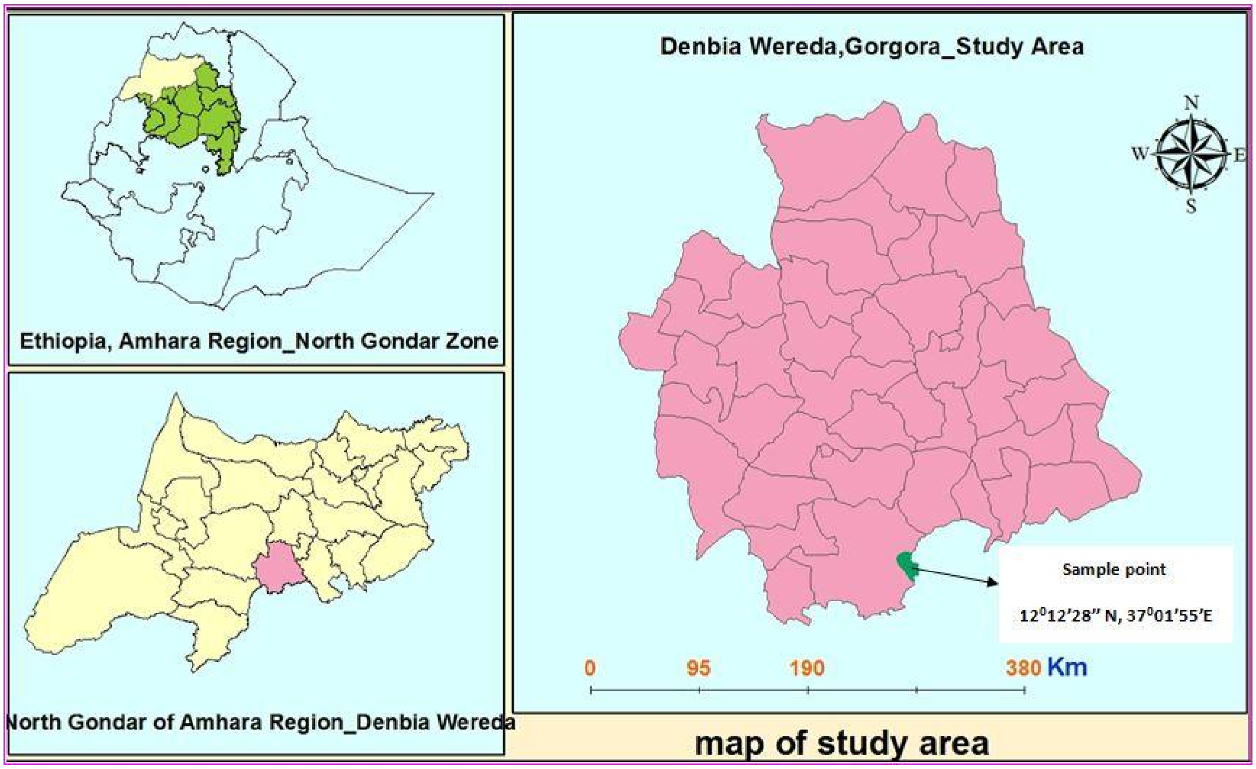

Figure 1. Location map of Gorgora kebele

3.2. Experimental Treatments and Designs

The experiment was conducted in 2016/17 cropping season under rain-fed condition. Improved maize variety (*Zea mays L.)*of BH-540, widely used in the study area, was used as a test crop. The treatments were factorial combination of three rates of compost (0, 5 and 10 ton ha^{-1}) and five rates of inorganic fertilizers (0, 100, 200, 200+ kg ha^{-1} blended fertilizers and 200kg ha^{-1} DAP) with 200kg urea. The field experiment was laid out in randomized complete block design (RCBD) with three replications. Each replication was divided in to 15 plots measuring 3.2m x 3.2m (10.24m^{2}) with 0.5 m spacing between plots and 1m spacing between replications. The net plot size of the experiment was 5.12m^{2}.

Table 1. List of treatment combination in the study area

Treatments	
T 1	Control
T 2	100 kg blended without compost
T3	200 kg blended without compost
T 4	200+ kg blended without compost
T 5	200 kg DAP without compost
T6	5 ton compost without blended
T7	5 ton compost +100 kg blended
T8	5 ton compost +200kg blended
T 9	5 ton compost +200+kg blended
T10	5 ton compost + 200kg DAP
T11	10 ton compost without blended
T12	*10 ton compost* +100 kg blended
T13	*10 ton compost* +200kg blended
T14	*10 ton compost* +200+kg blended
T15	*10 ton compost* + 200kg DAP

Blended fertilizer =Formula 3 (NPKSB) : haves 13.7N-27.4P2O5-14.4K2O+5.4 S+0.54B from 100 kg of blended fertilizer , 200+kg blended contain (200kg +48kg DAP +38 kg TSP fertilizers) to be equalize the amount of NP content of DAP fertilizer.

3.3. Experimental Procedure

3.3.1. Compost preparation and analysis

For the preparation of compost the following materials were used: wet material such as (weeds, grasses, and leaves of trees) and dry materials maize straw, cow dung and forest soil and ashes with a proportion of 3:1:1:0.01:0.05 weight base at the age of three month and applied at dry base. The nutrient contents of the prepared compost (OC, total N and available P, exchangeable K,), it's C: N value while compost physical properties such as bulk density and moisture content were determined in the laboratory before application. Content of OC was determined by Walkley and Black method (Walkley and Black, 1934), total N by Kjedahl method (Jackson,1958), and available P using Olsen method (Olsen, *et al*,1954), Its Bulk density and moisture content of compost were done from undisturbed soil oven dry(105^0C) with 24 hrs and calculated (Sahlemedhin and Taye, 2000).

3.3.2. Soil sample collection and physicochemical analysis

Soil samples were collected in two phases namely before planting and after harvesting the test crop. Composite soil samples were collected from the surface soil (0 – 0.2m depth) of each block before planting and from each treatment after harvesting .All collected soil samples were air dried at room temperature, ground and passed through 2 mm sieve except for OC and TN parameters (passed through 0.5mm).

Soil samples were further analyzed for texture by the hydrometer method (Sahlemedhin and Taye, 2000). Soil pH was measured in suspension of 1:2.5 soils to water ratio (Chopra and Kanwar, 1976). Soil Bulk density (Bd) was determined from undisturbed soil samples using core samplers (Rowell, 1997). Total N was determined by Kjedahl method (Jackson, 1958), available P of the soil determined by extraction with the help of 0.5 M $NaHCO_3$ for 30 minutes (Olsen *et al*., 1954), CEC and exchangeable Ca, Mg, K & Na were extracted with 1M NH_4OAc at pH 7 (Sahlemedhin and Taye, 2000). CEC was determined by ammonium acetate method, Ca, Mg determined by EDTA method and K, Na also determined by flame photometer. Soil OC was determined by Walkley and Black method (Walkley and Black, 1934), percent OM was calculated by multiplying percent OC by a factor of 1.724.

3.3.3. Land preparation and sowing

The experimental field was plowed two times and then leveled for plot preparation. The space between each row was 0.80 m and the space between each maize seed and fertilizer placements were 0.40 m (based on the guideline for maize extension package, 2015). Compost was applied before a one month of planting, 200 kg Urea ($CO(NH_2)_2$) applied after planting at knee height stages. Other fertilizer types were applied at planting time.

3.4. Data Collection and Measurements

The following yield and yield related characteristics of maize crop were recorded.

Cob length (cm): cob length was measured from ten randomly selected cobs at harvesting time from each plot and the average was recorded as cob length (cm) per plot.

Cob weight (gm): Cob weight was recorded from earlier selected cobs at harvesting from each plot and then average was recorded as cob weight per plot and then per ha.

Number of grains per cob: Numbers of grains per cob were recorded by counting the grains from sampled cobs.

Total above ground biomass (ton/ha): Total above ground biomass was measured from each net plot after harvesting and air drying.

Grain yield (ton/ha): Grain yield of each net plot was weighed in grams and converted in to yield in ton /ha. According to Kenedy (2004), the yield was adjusted at 13% of moisture content by formula of (1- current moisture content)/ (1-0.13)*grain yield.

Harvest index: harvest index was calculated the following equation: Harvest index (%) = (Economic yield / Biological yield) × 100 (Lemcoff and Loomis, 1994).
Thousand seed weight (gm): Thousand seed weight was measured from the count of thousand seeds after sun - drying using sensitive balance.

3.5. Statistical Analysis

The selected data were subjected to analysis of variance (ANOVA) appropriate to the design of the experiment using SAS (version 9.2) software. Mean separation was for statistically significant different treatment carried out using LSD at 5% probability levels.

3.6. Partial Budget Analysis

The Dominance analysis procedure as detailed in CIMMYT (1998) was used to select potentially profitable treatments from the range that was tested. The selected and discarded treatments using this technique are referred to as Undominated and Dominated treatments respectively. The Undominated treatments were ranked from the lowest (the farmers' practice) to the highest cost treatment. For each pair of ranked treatments, % marginal rate of return (MRR) was calculated. The % MRR between any pair of treatments denotes the return per unit of investment in fertilizer (organic & inorganic) expressed as a percentage. To obtain an estimate of these returns, the MRR was calculated by the following formula:

MRR (between treatments, a & b) = change in NB (NB_b-NB_a)/ Change in (TVC_b-TVC_a)*100

4. RESULTS AND DISCUSSION

4.1. Selected soil physical and chemical properties

The physical and chemical properties of the soil prior planting are shown in Table 3. The soil was clay loam in texture and had a pH of 6.38 which is slightly acidic, (Murphy, 1968 and Tekalign 1991). The soil available P was medium, (Cottenie 1980), CEC, was high, (Murphy 2007) and the exchangeable cations (K, Na, Ca and Mg) were also high except Sodium, which was medium (FAO 2006). The percentage of nitrogen and organic matter were moderate, (Tekalign, 1991).

Table 2. Before planting average physical and chemical properties of soil

Soil properties		Value	Status
pH (H_2O) 1:2.5		6.38	Slightly acidic
O.M (%)		3.06	Medium
TN (%)		0.15	Medium
Available P (mg kg^{-1})		12.16	Medium
CEC (cmol $_{(+)}$ kg^{-1})		36.53	High
Exchangeable bases	Ca (cmol$_{(+)}$ Kg^{-1})	19.56	High
	Mg (cmol$_{(+)}$ Kg^{-1})	6.02	High
	K (cmol$_{(+)}$ Kg^{-1})	0.83	High
	Na (cmol$_{(+)}$ Kg^{-1})	0.34	Medium
Bulk density		1.18gm/cm^3	
Particle sizes:	Sand (%)	28.77	
	Clay (%)	40.00	
	Silt (%)	31.23	
Texture class		Clay loam	

4.1.1. Nutrient content of compost before incorporated to the field

The application of soil amendments by compost (organic fertilizer) as the major treatment of the study improved the chemical and physical characterstic of the soil. The OC content of compost was 25.85%, total N (1.7%), available P (204.31 mg kg^{-1}), exchangeable K was

24.86 cmol kg^{-1} and C: N ratio was calculated as 15.14. Bulk density 0.83 g cm^{-3} and its moisture content of compost also 20.5%. The values indicated that the compost could be used to potentially enhance the fertility status of the soil. Similar result showed that compost had moisture content (14.73%), total N (1.74%), available P (390 mg kg^{-1}) and exchangeable K (24.86 cmol kg^{-1}). The OC contents of 22.50% and C: N ratio of 15.30 (Zarinaet al., 2010).

4.1.2. Soil chemical and physical properties after harvesting

Selected physico-chemical properties of the soil from the experimental field before planting and after harvesting is presented in Table 3 and 4, respectively. The soil pH value before the application of organic and inorganic fertilizer was 6.38 which was (slightly acidic). The soil pH range after harvest was 6.28 – 6.38 (slightly acidic). However, plots receiving higher amounts of organic and inorganic fertilizer recorded the lowest pH values than control because of releasing H ion by organic matter mineralization and nitrogen fertilizer oxidation (Table 4). Generally, there was a slightly reduction in soil pH value by about 0.01 to 0.1 units. All the treatments after harvest indicating an increase in soil acidity, with blended and organic fertilizers values (Table 4). Quansah (2010) stated that generally, there was a drop in the pH of all the treatments after harvest indicating an increase in soil acidity, with inorganic (N) and organic fertilizer values decreasing by about one pH unit.

Before planting, the soil organic matter (OM) content of the experimental site was medium (3.06 %). However, after harvesting the soil OM ranged from medium to high (3.60 to 4.41%). The highest soil OM was recorded on the plots which received 10 ton ha^{-1} compost (Treatment 11 up to15). Similarly, total nitrogen (TN) content varied from its medium status before planting (0.15%) after harvesting (0.13 to 0.24%) medium to high according to Murphy (1968). Soil TN after harvesting showed a slight decrease than before planting status on control plots and on plots with blended fertilizers only. This could be related to N uptake by the growing maize crop or other N losses (leaching, volatilization). Conversely, TN showed a slight increase on plots with higher compost treatments (Treatment 11 – 15) which might be related to mineralization of organic N. Hanway (1971) observed that N tends to be depleted rapidly from the soil with cash grain farming such as maize. According to nutrient ratings suggested by (Cottenie, 1980) soil available phosphorus status was medium (12.6 mg kg^{-1}) at pre planting as compared to after harvesting where almost all plots except the control plots showed sufficient and above available P status (15.4 – 58.6 mg kg^{-1}) (Table 4). Soil exchangeable potassium was high (0.83 cmol $_{(+)}$ kg $^{-1}$) on all plots before the experiment. The levels of exchangeable potassium after harvest however, ranged from high to very high (0.88-1.83 cmol/kg of soil) with most of the plots having high exchangeable K specially plots which were receiving blended and integrated fertilizer application because of K_2O nutrient was a component of blended fertilizer and compost also have balanced nutrients in small amount.

Organic acids available in organic fertilizer can chelate toxic elements (metals) in soil so that soil condition is not harmful for crop growth. Organic acids are capable to decrease phosphate quantity which fixed by Fe and Al through chelating mechanisms so that P is become available for crops (Barker dan Pilbeam, 2007).

Table 3. Residual effect of organic and blended fertilizer application on soil fertility after harvesting

Treatments	Parameters								
	pH(H_2O)	TN	OM	Av.P	CEC and Exchangeable bases (cmol$_{(+)}$kg^{-1})				
	1:2.5	%	%	mgkg $^{-1}$	CEC	Ca	Mg	K	Na
1	6.38	0.12	3.60	10.36	38.07	21.4	4.71	0.88	0.51
2	6.37	0.12	3.62	18.77	38.17	21.6	4.60	1.13	0.35
3	6.36	0.14	3.60	18.94	38.32	20.80	5.03	1.16	0.33
4	6.36	0.14	3.63	20.33	39.69	21.20	3.42	1.15	0.42
5	6.37	0.13	3.62	34.02	38.10	21.35	4.12	1.66	0.44
6	6.36	0.17	4.02	15.42	42.89	23.33	4.85	1.06	0.32
7	6.35	0.16	4.05	26.43	43.31	22.86	4.96	1.17	0.31
8	6.34	0.15	4.03	42.00	43.41	23.12	5.12	1.83	0.32
9	6.30	0.17	4.05	43.43	43.19	23.64	4.56	1.98	0.31
10	6.36	0.16	4.08	46.72	43.62	23.85	5.10	1.18	0.33
11	6.30	0.21	4.38	20.58	45.84	25.04	4.96	1.05	0.31
12	6.34	0.20	4.35	49.76	44.93	24.96	5.08	1.24	0.34
13	6.32	0.19	4.36	51.10	45.15	24.87	5.18	1.62	0.33
14	6.28	0.20	4.32	58.60	45.61	25.12	5.10	1.83	0.31
15	6.29	0.20	4.41	56.03	45.52	25.10	5.21	1.23	0.30

4.2. Analysis of Variance

The experiment was conducted with the main objectives to determine the effect of integrated application of organic and blended fertilizers on maize grain yield, yield components, as well as enhancing soil fertility. In view of these various parameters were measured and statistically analyzed. Analysis of variance (Table 4, 5 and 6) revealed that the main effect and interaction effect of organic and inorganic fertilizer application was significant in influencing the number of grains/cob, cob weight, thousand seed weight, grain yield, biomass yield at 0.05 probability level. Only one parameters, harvest index at main and interaction of organic and inorganic fertilizers application at 0.05 probability level was not significant (Table 4, 5 and 6).

Table 4. Main effect of organic fertilizers on grain yield and yield attributes

treatment	GY	BMY	HI	NGC	CL	CW	TSW
control	6.87[c]	13.07[b]	0.53[a]	407.00[b]	3.33[c]	96.33[c]	522.73[b]
5 ton/ha	7.59[b]	14.98[a]	0.51[a]	451.75[a]	5.17[b]	133.94[b]	540.06[a]
10 ton/ha	8.21[a]	15.17[a]	0.54[a]	445.67[a]	6.33[a]	206..95[a]	546.20[a]
GM	7.56	14.41	0.52	434.81	4.94	145.74	534.33
CV (%)	2.71	2.57	4.03	2.95	9.83	5.52	0.94
LSD (5 %)	0.47**	0.84**	ns	29.10*	1.10**	18.23**	11.37*
EMS±	0.042	0.14	0.001	164.81	0.24	64.66	25.15

GY= grain Yield per hectare, BMY=Biomass yield per hectare HI= Harvest index, NGC=Grain per cob, CL=cob length, CW=Cob weight, TSW= Thousand seed weight.

Table 5. Main effect of inorganic fertilizers on grain yield and yield attributes

treatment	GY	BMY	HI	NGC	CL	CW	TSW
control	6.87^{c}	13.07^{d}	0.53^{b}	407.00^{c}	3.33^{d}	96.33^{d}	522.73^{d}
100 kg/ha of BF	8.22^{b}	14.15^{c}	0.58^{a}	452.75^{b}	5.50^{c}	174.08^{c}	538.50^{c}
200 kg/ha of Bf	8.81^{ab}	14.99^{b}	0.59^{a}	469.75^{ab}	6.33^{bc}	200.93^{bc}	554.54^{b}
200+ kg/ha of BF	8.93^{a}	14.96^{b}	0.59^{a}	483.17^{a}	7.00^{ab}	248.71^{b}	563.00^{a}
200kg/ha of DAP	8.93^{a}	16.15^{a}	0.55^{ab}	481.17^{ba}	8.00^{a}	322.84^{a}	551.81^{b}
GM	8.35	14.66	0.57	458.77	6.03	208.58	546.12
CV (%)	3.87	2.56	5.14	3.37	12.70	12.85	0.38
LSD (5 %)	0.61**	0.71**	ns	29.12**	1.44**	50.46**	3.93**
EMS±	0.11	0.14	0.001	239.21	0.59	718.11	4.36

BF= Blended fertilizer which is recommended for working area GY= grain Yield in ton per hectare, BMY=Biomass yield in ton per hectare HI= Harvest index, NGC= number of grain per cob, CL=cob length, CW=Cob weight, TSW= Thousand seed weight

4.3. Main and Interaction Effect of Compost and Inorganic Fertilizers on Yield Attributes and Grain Yield

4.3.1. Cob length

The longest cob length (8.5cm) was found in (treatment14) where 200+kg ha^{-1} blended fertilizer and 10 ton compost was applied. This result was not significantly different ($p > 0.05$) to treatment number 15 where 200kg DAP and 10 ton compost was applied. However, a significant difference ($P < 0.05$) cob length was observed in control plots (3.3 cm) .To compare the average cob length of organic, inorganic and interaction of organic and inorganic fertilizer were 4.94 cm, 6.03 cm and 7.09 cm respectively (Table 4,5 and 6). Similarly, Sarhad (2011) reported that longer ear length of 14 and 13.5 cm was recorded when 240 and 300 kg ha^{-1} N was used respectively while the smallest ear length of 11.4 cm was recorded in control plots where N was not applied. This might show the direct relationship between the highest cob length and high input.

4.3.2. Cob weight

The highest cob weight (374.87gm) was found in (treatment 15) where 200kg DAP fertilizer and 10 ton compost application and not a significant variation to (treatment14) 200+kg blended fertilizer with 10 ton compost application per hectare but differ significantly to shortest cob (96.33gm) which was found in control plot. To compare the average cob weight of organic, inorganic and interaction of organic and inorganic fertilizer were 145.74 gm, 208.58 gm and 304.58 gm respectively(table 4,5 and 6). This might show the highest cob weight has direct relationships with integration and high input applications.

4.3.3. Number of grain per cob

The analysis of variance indicated that highly significant ($P<0.05$) number of grain per cob difference due to the application of main factor of organic, inorganic fertilizer and their interactions. Maximum number of grains per cob (499.58) was found in 200kg DAP fertilizer with 10 ton compost application per hectare which differ significantly to minimum number of grains per cob (407 was found in control plot). Grain yield is directly related to number of grains per cob. The more number of grains per cob results in more grain yield. To compare the average number of grain per cob of organic, inorganic and interaction of organic and inorganic fertilizer were applied 434.81, 458.77 and 466.61grains found respectively (table 4,5 and 6).

The number of grains per cob is a genetically controlled factor but environmental and nutritional level may also influence the number of grains per cob (Muhammed *et al,*. 2008). Nitrogen affected number of grains ear-1 of maize hybrids at 1% probability level. Significantly higher number of 481.2 grains ear-1 was recorded when 300 kg ha-1 N was used, which was at par with number of grains cob^{-1}recorded at 240 or 180 kg ha-1 N. The lowest number of 295.6 grains ear-1 was recorded from the control plot (Sarhad, 2011).

4.3.4. Weight of thousand grains

The treatment T_{12} (100 kg blended fertilizer and 10 ton compost ha^{-1}) produced the maximum 1000 grain weight (564gm) which was significantly different from the rest of all the treatments (Table 6). T_{14} (200+kg blended fertilizer and ten ton compost application ha^{-1}, T_{15} (200kg DAP fertilizer and ten ton compost application ha^{-1}) also gave a higher 1000 grain weight over others. The minimum weight of 1000 grains was obtained in T_1 (control). To compare the average weight of thousand grains of organic, inorganic and interaction of organic and inorganic fertilizer were applied 536.33 gm, 546.12 gm and 549.29 gm found respectively (table 4, 5 and 6). Onasanya *et al.* (2009) reported that, the treatment (120 kg N ha^{-1} + 40 kg P ha^{-1}) produced the maximum 1000 grain weight which was significantly different from the rest of all the treatments, (60 kg N ha^{-1} + 40 kg P ha^{-1}) also gave a higher 1000 grain weight over others while, the minimum weight of 1000 grains was obtained in control. This might show the highest weight of thousand grains have direct relationships with integration and high input applications.

4.3.5. Biomass yield

The analysis of variance indicated highly significant ($P<0.01$) biomass yield differences due to the application of organic, inorganic and their interactions (Table 6). Blended fertilizers application also showed biomass yield increment but not linear and consistent. The average maize biomass yield for the various inorganic fertilizers treatments yield ranged from 13 to 16.15 ton/ha with a yield increment of 8.84 to 24.23% over the control treatment, respectively. To compare the average weight of biomass yield of organic, inorganic and interaction of organic and inorganic fertilizer were applied 14.41 ton ha^{-1}, 14.66 ton ha^{-1} and 15.00 ton ha^{-1} found respectively. This observation is consistent with findings of other researchers who reported higher biological yield (11830 kg ha^{-1}) was recorded when 300 kg ha^{-1} N was used which was at par with the biological yield produced at 240 kg ha^{-1} N. The lowest biological yield of 7545 kg ha^{-1} was recorded in control plots where nitrogen was not applied (Inamullah *et. al.,* 2007). In this study, the biomass yield was not with the higher rate blended fertilizer. The ammount greater than 100 kg/ha lower the biomass yield probably be the tocix effect of boron, whereas increasing DAP fertilizer shows increasing the biomass (table 6), this shows that there are nutrient negative interaction especially micro nutrients such as boron, but to confirm thse further nutrient omission trial is obligatory.

4.3.6. Grain yield

The analysis of variance indicated highly significant ($P<0.05$) grain yield differences due to the application of compost (organic fertilizers). The average maize grain yield ranged from 6.87 to 8.21 ton/ha (Table 4) with the increment of 10.4 to 19.5% over the control treatment, respectively.

Similarly, increasing inorganic fertilizers levels from 0 to 200 kg /ha blended fertilizers application also showed linear and consistent grain yield increment due to inorganic fertilizer application. The average maize grain yield for the various inorganic fertilizers treatments yield ranged from 6.87to 8.93 ton/ha (Table 5) with a yield increment of 19 to 30% over the control treatment, respectively. On the other hand the interaction effect of organic and inorganic fertilizer showed that average maize grain yield increment from 6.87 to 9.45 ton/ha (Table 6) with the yield increment of 28 to39% over the control treatment , respectively.

Application of organic or inorganic fertilizers increased significantly the grain yield compared to unfertilized plots. This can be ascribed to the positive effect of fertilizers in improving soil fertility. This effect is very pronounced when organic manure is combined with inorganic (chemical) fertilizer application (Table 4,5 and 6). De Ridder and Van Kaulem (1990) reported that the use of both inorganic and organic fertilizers often results in synergism and improvement of nutrient and water use efficiency. The inorganic fertilizer provides (a large part of) the nutrients and the organic fertilizer increases soil organic matter status, structure, and buffering capacity (Maatman et al., 2007). The organic matter also improves phosphorus (P) availability through reduction of the P sorption capacities of the soil (Easterwood and Sartain, 1990; Nziguheba et al., 2000; Nziguheba, 2007) .

To examine the relative yield performance of organic and conventional farming systems globally, available data shows that, overall, organic yields are typically lower than the conventional yields. But these yield differences are highly contextual, depending on system and site characteristics, and range from 5% lower organic yields (rain-fed legumes and perennials on weak-acidic to weak-alkaline soils), 13% lower yields (when best organic practices are used), to 34% lower yields (when the conventional and organic systems are most comparable). The average organic-to-conventional yield ratio from our meta-analysis is 0.75 (with a 95% confidence interval of 0.71 to 0.79); that is, overall, organic yields are 25% lower than conventional (nature, 2012). Similarly In these study organic yield was lower than conventional yield from 7.66 to 15% without partial budget and environmental impact analysis (table5 and 6). According to (Jayne *et al.2008),* The higher yields from organic materials plus inorganic fertilizer treatments compared to the recommended rate of inorganic fertilizer is an indication that integrated use of organic and inorganic nutrient sources are advantageous over the use of inorganic fertilizer alone.

When organic systems receive higher quantities of N than conventional systems, organic performance improves, whereas conventional systems do not benefit from more N. In the other words, organic systems appear to be N limited, whereas conventional systems are not. Indeed, N availability has been found to be a major yield-limiting factor in many organic systems. The release of plant-available mineral N from organic sources such as cover crops, compost or animal manure is slow and often does not keep up with the high crop N demand during the peak growing period.

There are many factors to consider in balancing the benefits of organic and conventional agriculture, and there are no simple ways to determine a clear 'winner' for all possible farming situations. However, instead of continuing the ideologically charged 'organic versus conventional' debate, we should systematically evaluate the costs and benefits of different management options. In the end, to achieve sustainable food security we will probably need many different techniques—including organic, conventional, and possible 'hybrid' systems to produce more food at affordable prices, ensure livelihoods for farmers, and reduce the environmental costs of agriculture Nature (2012).

This observation is consistent with findings of other researchers who reported higher maize yields in plots that had organics plus fertilizer compared to sole application of inorganic fertilizers (Esilaba *et al*., 2005; Kimetu *et al*., 2004; Mugendi *et al*., 1999). This implies that integration of inorganic and organic nutrient inputs enhances nutrient use efficiency. The integrated use of organic nutrient sources with inorganic fertilizer was shown to increase the potential of organic fertilizer and to improve the efficiency of inorganic fertilizers, (Heluf, 2002). The combination of organic nutrient resources and mineral fertilizers has been shown to result in synergy and improved synchronization of nutrient release and uptake by crop (Palm *et al*., 1997), as well as and a more balanced supply of nutrients (Donovan and Casey, 1998) leading to higher yields.

Table 6. Interaction effect of organic and blended fertilizers on grain yield and yield attributes

treatment	GY	BMY	HI	NGC	CL	CW	TSW
control	6.87f	13.07e	0.53de	407.00d	3.33j	96.33h	522.73f
100 kg/ha of BF	8.22d	14.15d	0.58bcd	452.75c	5.50hi	174.08f	538.50e
200 kg/ha of Bf	8.81c	14.99bcd	0.59abc	469.75bc	6.33fgh	200.93ef	554.54bcd
200+ kg/ha of BF	8.93bc	14.96bcd	0.59abc	483.17ab	7.00efg	248.71d	563.00a
200kg/ha of DAP	8.93bc	16.15a	0.55cde	481.17ab	8.00abc	322.84bc	551.81cd
5 ton/ha	7.59c	14.98bcd	0.51ab	451.75bc	5.17i	133.94g	540.01e
100 kg+5ton/ha	8.81e	14.68bcd	0.60e	459.50c	6.17gh	302.99e	515.40f
200 kg+5ton/ha	9.04abc	15.07bcd	0.60ab	464.25bc	7.17def	305.08c	547.90d
200+ kg+5ton/ha	9.02bc	15.45abc	0.59abc	467.67bc	7.33cde	305.82c	561.79ab
200kgDAP+5ton/ha	9.21abc	15.57abc	0.59abc	470.17bc	7.50bcd	311.34c	549.90cd
10 ton/ha	8.21d	15.17abc	0.54cde	445.67c	6.33fgh	206..95e	540.20e
100kg+10ton/ha	9.13abc	15.83ba	0.58bcd	485.92ab	7.33cde	329.83bc	564.00[a]
200kg+10 ton/ha	9.08abc	15.05bcd	0.60ab	465.50bc	8.50a	346.94ab	563.09a
200+kg+10ton/ha	9.45ab	15.08bcd	0.63a	479.92ab	8.17abc	368.01a	561.53ab
200kg DAP+10ton/ha	9.56a	15.20abc	0.63a	499.58a	8 .33ab	374.87a	557.27abc
GM	8.73	15.03	0.58	465.58	6.81	268.58	548.78
CV (%)	3.71	4.18	6.02	3.44	7.84	6.88	0.83
LSD (5 %)	0.54**	1.05**	ns	26.78**	0.89**	30.92**	7.61**
EMS±	0.11	0.39	0.001	256.37	0.29	341.79	20.71

There was statistical difference between the sole use of organic and inorganic fertilizers as well as the integrated application which shows in (Table 5,6 and 7), the highest yield (9.56 and 9.45 ton/ha) found from T14 and T15 (integrated), the sole use of fertilizer application (200kg blended fertilizer(T3)) productivity (8.81 ton/ha) was lower than the integration application of half blended and 10 ton /ha compost (9.13 ton/ha) and almost equal production to 5 ton compost with 100 kg blended fertilizer application (T6).

4.3.7. Harvest index

Harvest index describes plant capacity to allocate biomass (assimilates) into the formed reproductive parts; in which grain yield is a product of harvest index and biomass yield. In this paper, a visualization technique is proposed to give insight into associations among harvest index, biomass yield and grain yield.

Sarhad (2011) documented that, nitrogen affected harvest index (HI) of maize hybrids significantly at P 0.01. Higher HI of 31.4% was recorded in plots applied with 300 kg ha^{-1} nitrogen, which was not statistically different from the HI of 30.1% recorded at 240 kg ha^{-1} N. The lowest HI of 21.1% was recorded in plots where nitrogen was not applied. While Ali *et al.* (2002) reported that, HI was not affected with change in nitrogen level. In these study the analysis of variance indicated that main and interaction effect of organic and inorganic fertilizers did not affect harvest index at (P<0.05) (Table 4,5and 6).

4.4. Correlations among Yields, Yield components and Harvest Index of Maize

Correlation analysis result revealed that there was a highly significant (P < 0.01) and positive correlation between yield attribute and grain yield of maize (Table 7). Grain yield was significantly and positively correlated with cob weight (r = 0.78**), cob length (r = 0.76**), number of grains per cob (r = 0.74**), biomass yield (r = 0.59**), and thousand seed weight (0.58**). In conformity with this finding ,Inamullah *et al.* (2011b) found that ,Ear length showed positive and significant (P < 0.05) correlation with 1000grains weight (r = 0.681*) while positive and highly significant (P < 0.01) correlation with grains cob^{-1} (r = 0.872**), grain yield (r = 0.724**) and biomass yield (r = 0.748**). Similarly, Rafique *et al.* (2004) reported positive correlations (P < 0.05) of ear length with 1000 grain weight and grain yield. In the other (Selvaraj, 2011) however, reported negative correlations of grains cob^{-1} with 1000 grain weight (r = -0.084), grain yield (r = -0.359) and biomass yield $plant^{-1}$ (r = -0.166) and they reported that grains cob^{-1} is correlated with cob height on the plant only, while grain yield is correlated with the number of cobs m^{-2} instead of 1000 grain weight and grains cob.

Table 7. Correlation between grain yield and some yield related traits of maize

	GY	NGC	HI	BMY	CL	CW
GY						
NGC	0.74**					
HI	0.72**	0.42**				
BMY	0.59**	0.56**	-0.14ns			
CL	0.76**	0.66**	0.54**	0.46**		
CW	0.78**	0.65**	0.59**	0.45**	0.90**	
TSW	0.58**	0.59**	0.36*	0.42**	0.68**	0.53**

4.5. Partial Budget Analysis

Gross return was calculated from price (seasonal average) of maize grain and straw in the study area (maize grain 4500 Eth. Birr per ton whereas straw 400 Eth. Birr per ton by January 2017). Variable cost was calculated from the costs involved for purchase and application of fertilizer. Blended fertilizer (NPKSB), DAP, Urea and compost were purchased for 1336.93, 1368.16, 1017.35 birr per quintal and 363.6 birr per ton, respectively. For application of the fertilizer, 300 Birr per ha for blended and DAP, for split application of Urea fertilizer 400 Birr per ha and 500 birr to apply 5 ton compost per ha were needed. The benefit of compost should be consider for least three years to releasing nutrient for plant and improving soil biological and physical properties.

The input and output prices used in the economic analysis were those prevailing during the period of the experiment. Market prices are ever changing and as such a recalculation of the partial budget using a set of likely future prices i.e., sensitivity analysis, is necessary to pinpoint treatments which are likely to remain stable and sustain acceptable returns for farmers despite price fluctuations.

As presented in Table 8 treatment except treatment 3 and 5 all were not found profitable because of dominated and < 100% of MRR. However to be consider soil fertility improvement with high productivity of maize, Treatment 7 and treatment 12 should be profitable and soil fertility as sustainable Woy. The sensitivity analysis also indicated that result withstood 10% price and yield fluctuations. Detail partial budget analysis is presented in table 1, 2 and 3.

Table 8. Partial budget analysis

Treatment	Labor cost for Input application	Input price Eth bir	Total variable Cost. Eth bir	Gross benefit Eth bir	Net benefit Eth bir	MRR %	Sensitivity Analyses 10%
T1	0.00	0.00	0.00	36143.00	36143.00	-	-
T6	500.00	606.00	1106.00	40147.00	3904.00	52	41.33
T2	700.00	3371.63	4071.63	42650.00	38578.37	71	16.78
T11	1600	3636.00	5236.00	43013.00	37777.00	D	D
T3	700.00	4708.56	5408.56	45641.00	40232.44	1422	83.04
T5	700.00	4771.02	5471.02	46645.00	41173.98	1507	1215.28
T7	1200.00	5189.63	6389.63	45517.00	39127.37	D	D
T4	700.00	5778.10	6478.10	46169.00	39690.9	D	D
T8	1200.00	6526.56	7726.56	46780.00	38981.44	D	D
T10	1200.00	6589.02	7789.02	47673.00	39883.98	D	D
T12	1700.00	7007.63	8707.63	47417.00	38709.37	D	D
T9	1200.00	7596.10	8796.10	46370.00	37573.90	D	D
T13	1700.00	8344.56	10044.56	46880.00	36834.44	D	D
T15	1700.00	8407.02	10107.02	49100.00	38992.98	D	D
T14	1700.00	9414.10	11114.10	48557.0	37442.90	D	D

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Application of 5 ton ha^{-1} compost and 50% recommended inorganic fertilizer could increase soil properties and could produce the same yield as that of treatments where 200 kg ha^{-1} inorganic fertilizer was applied. However, application of 10 ton ha^{-1} organic fertilizer together with 50% of recommended fertilizer showed better soil properties and significantly different ($P < 0.01$) maize grain yield (9.13 ton ha^{-1}) than the sole application of 200 kg ha^{-1} mineral fertilizer (8.81 ton ha^{-1}).

Meanwhile, the comparative yield of the previous fertilizer recommendation 200kgDAP to revised recommended rate of blended fertilizer rate showed that still the previous recommended rate had a greater grain yields than current recommended rate of fertilizer..

5.2. Recommendation

From the result of the experiment, treatment 5 (200 kg DAP ha^{-1} with split application of 200 kg ha^{-1} urea) is recommended in order to increase maize crop productivity. Meanwhile, application of 10 ton compost ha^{-1} +100 kg blended fertilizers with split application of 200 kg urea ha^{-1} can also bring an increase in yield of maize and improve soil fertility status. This will greatly benefit farmers in area were farmers cannot afford the cost of high fertilizer input. However, it is also necessary to develop further research such as nutrient omission trial to verify nutrient to nutrient interaction before recommendation of blended fertilizers especially the micro nutrient such as boron and other .Overall, soil test based fertilizer application is optional because micro nutrients are not only essential but also toxic if there are excess

6. REFERENCES

Adejumo, S.A., A.O. Togun, J.A. Adediran and M.B. Ogundiran, (2010).Effects of compost application on remediation and the growth of maize planted on lead contaminated soil, Department of Crop Protection and Environmental Biology, University of Ibadan, Ibadan. Nigeria, 19th World Australia. Published on DVD.

Adrien, N., A. Drapeau and C. Nduwamungu, (2010). Fresh and Composted Paper Sludges Sustain Soil Productivity. *Hindawi Publishing Corporation International Journal of Agronomy.*58: 49-60.

Ali, J., J. Bakht, M. Shafi, S. Khan and W. Ali, (2002). Uptake of nitrogen as affected by various combinations of Nitrogen and Phosphorus. Asian J. Plant Sci. 1(4): 367-369.

Allison, F.E., (1973). Soil organic matter and its role in crop production U.S. Department of Agriculture, Washington, D.C., U.S.A. Elsevier

Andrén, O., J.Kihara, A. Bationo, B. Vanlauwe and T. Kätterer,(2007). Soil Climate and Decomposer Activity in Sub-Saharan Africa Estimated from Standard Weather Station Data-A Simple Climate Index for Soil Carbon Balance Calculations. Ambio. *36*: 379- 386.

Andrien, N. and T.S. Tran, (2001). Effects of green manures on soil organic matter and wheat yields andN nutrition, *Canadian Journal of Soil Science*. 81: 371–382.

Agricultural Transformation Agency (2012), Agricultural Production in Ethiopia: Results of the 2012 ATA Baseline Survey. *Research for Agriculture policy*

Agricultural Transformation Agency (2013), Agricultural Production in Ethiopia: Results of the 2013 ATA Baseline Survey. Maize sector development strategy working document

Agricultural Transformation Agency (2015), Agricultural Production in Ethiopia: Results of the 2015 ATA Baseline Survey. *Maize sector development strategy working document*

Asrar-ur-Rehman SU, Saleem M, Subhani GM (2007).Correlation and path coefficient analysisin Maize (zea mays l.). J. Agric. Res., 45: 177-183.

Barker dan pilbean, (2007). Handbook of Plant Nutrition. Second Edition Edited by Allen V. Barker and David J. Pilbeam CRC Press 2015 Pages 745–760

Basavaraju, S.D., (2007). Integrated nitrogen management in maize (*Zea mays* L.) in a vertisol of Malaprabha command area,Department of Soil Science and Agricultural Chemistry.

Bationo, A., J. Kimetu, S. Ikerra, S. Kimani, D. Mugendi, M. Odendo, M. Silver, M.J. Swift and N. Sanginga, (2004). The African network for soil biology and fertility: new challenges and opportunities. In: Managing Nutrient Cycles to Sustain Soil Fertility inSub-Saharan Africa. A. Bationo (Ed.). Academy Science Publishers. Nairobi.

Belay Simane, (2003). Integrated watershed management approach to sustainable land management (Experience of SARDP in East Gojjam and South Wollo). pp.127-136. *In*: Tilahun Amede (Ed.). *In*: Proceedings of the Conference on the Natural Resource Degradation and Environmental Concerns in the Amhara National Regional State: Impact of Food Security, July 24-26, 2002, Bahir Dar. The Ethiopian Society of Soil Science (ESSS). Addis Ababa,Ethiopia.

Beyer, D.M., (2003). Basic Procedures for Agaricus Mushroom Growing; Penn State University, University Park, Pennsylvania.

Brady, N.C. and R.R. Weil,(2002). The nature and properties of soils, 13th Ed. Prentice- Hall Inc., New Jersey, USA.

Brady, N.C. and R.R. Weil, (2005). The nature and properties of soils, 14thEdition. Macmillan Publishing Company, New York.

Camara, O. and E. Heinemann, (2006). Overview of the Fertilizer Situation in Africa - Background paper prepared for the African Fertilizer Summit. 9-13 June, 2006 Abudja, Nigeria. 21p. http://www.africafertilizersummit.org/, September 10, 2007.

Chandrashekara, S.I., H. Muralikrishan and G.K. Girijesh, (2000). Response of maize to organic manures with inorganic fertilizers. *Karnataka Journal of Agricultural Sciences*. 13: 144 - 146.

Carine, S., V. Degrange, R. Oliver, P. Millard, C. Commeaux, D. Montange and X.L. Roux, (2006). Alteration and resilience of the soil microbial community following compost amendment: effects of compost level and compost-borne microbial community.

Chaudhary, A.H., 1983. Effect of population and control of weeds with herbicides in maize. *Field Crop Abst*tract. 35(5): 403.

Chopra, S.H. and J.S. Kanwar, (1976). Analytical agricultural chemistry. Kalyani Publisher

CIMMYT, (1988). From Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition. Mexico, DF.

CSA (Central Statistics Authority) (2014). Agricultural sample survey.Report on area and crop production forecast for major grain crops (private peasant holdings, meher season), Statistical volume 4. Addis Ababa, Ethiopia.

Damene Darota, (2003). Yield response of bread wheat (*Triticum aestivum L.*) to applied levels of N and P fertilizers on Nitisol of Dawro Zone, Southwestern Ethiopia, MSc thesis unpublished.

De Ridder N, Van Keulen H (1990). Some aspects of the role of organic matter in sustainable intensified arable farming systems in the West-African semi-arid tropics (SAT), Fertil. Res., 26: 299-310.

Donovan, G. and Casey, F. (1998). Soil fertility management in Sub-Saharan Africa. *World Bank Technical Paper No. 408. World Bank. Washington, D.C.*

Edward, J. P., (1992). Soil science and management second edition, Delmar Publishers Inc.

Eghball, B. and J.F. Power, (1999). Phosphorus and nitrogen-based manure and compost applications: corn production and soil phosphorus. *Soil Science Society of America Journal.* 63:895-901.

Esilaba, A. O., Byalebek, J. B., Delve, R. J., Okalebo, J. R., Ssenyange, D., Mbalule, M. and Ssali, H. (2005). On farm testing of integrated nutrient management strategies in eastern Uganda. *Agricultural Systems 86:144*– 165.

ESSS (Ethiopian society of soil science),(2006). Soil for sustainable development. Proceeding of the eighth conference, aplril27-28).

FAO (Food and Agriculture organization), (2006), Plant nutrition for food security: A guide for integrated nutrient management. FAO, Fertilizer and Plant Nutrition bulletin 16, Rome.

Federal Ministry of Agriculture,(2003). Applying compost benefits and needs, Forestry, Environment and Water Management, Austria, and European Communities, Seminar proceedings Brussels.

Ferguson, R.B. and J.A. Nienaber, (1995). Utilization of nutrients derived from composted beef feedlot manure. Proc. Seventh International Symposium on Agriculture and Food Processing Waste. Education Charles Ross. 7:200-207.

Floret, C. and R. Pontanier, 2001. La jachère en Afrique tropicale : de la jachère naturelle à la jachère améliorée. Le point des connaissances. CTA, IRD, John Libbey Eurotext. Actes d'un séminaire, Dakar (Sénégal), 1999. 356 pp.

Frank, M., B. Allen, B. Steven and B, Peter, (2006).Compost uses and soil fertility.

Friew Kelemu and Girma Mamo, (2001). Suitable zones for growing maize in Ethiopia, Melkassa Research Center, P.O. Box 436, Nazret, Ethiopia, and Second National Maize Workshop of Ethiopia. 12-16 November, 2001 p. 195.

Gebeyaw Tilahun, (2007). Soil fertility status as influenced by different land uses in Maybar areas of South Wello Zone, North Ethiopia.

Ghosh, P.K., P. Ramesh, K.K. Bandyopadhyay, A.K. Tripathi, K.M. Hati, A.K. Misra and C.L.Acharya, (2004). Comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. I. Crop yields and system performance. Indian Institute of Soil Science, Nabibagh, Berasia Road, Bhopal 462038, Madhya Pradesh, India. Available online 1 April 2004.

Gisladottir, G. and M. Stocking, (2005). Land degradation control and its global environmental benefits. Land Degradation and Development. *16:* 99-112.

Harmsen, J., H.J. Velthorst and A.M. Bennehey, 1994. Cleaning of residual concentrations with an extensive form of land farming. p. 84-91. In: *Applied Biotechnology for Site Remediation*. (Eds.): R.E. Hinchee, D.B. Anderson, F.B. Meeting Jr. and G.D. Sayles. Lewis Publisher, Boca Raton, FL, USA.

Heluf Gebrekidane, (2002). Soil and water Management Research Program Summary Report of 2000/2001 Research Activities, P: 95. Alemaya Research Center, Alemaya University.

Henao, J. and C. Baanante, (2006). Agricultural production and soil nutrient mining in Africa: Implication for resource conservation and policy development. IFDC Tech. Bull. International Fertilizer Development Center. Muscle Shoals, Al. USA.

Hurni, H., (1988). Degradation and conservation of the resources in the Ethiopian highlands. Mountain Research and Development. 8 (2/3): 123-130

Hurni, H., 1993. Land degradation, famine, and land resource scenarios in Ethiopia. In: D. Pimentel (ed), World soil erosion and conservation. Cambridge University press.

Inamullah, N.H. Shah, Z. Haq and F.U. Khan. (2007). An analysis of the planting dates effect on yield and yield attributes of spring wheat. Sarhad J. Agric. 23(2): 269-275.

Inamullah, N. Rehman, N.H. Shah, M. Arif, M. Siddiq and I. Mian. (2011b). Correlations among grain yield and yield attributes in maize hybrids in various nitrogen levels. Sarhad J. Agric. 27(4): 531-538.

IITA (International Institute of Tropical Agriculture), (2007).Research for development cereals and legumes systems , maize.

International Food Policy Research institute, 2010. Fertilizer and soil fertility potential in Ethiopia, Constraints and opportunities for enhancing the system, working paper pp 2-3

International plant nutrition institute (2013), Influence of Plant Population and Nitrogen-Fertilizer at Various Levels on Growth and Growth Efficiency of Maize. Scientific World Journal. Volume 2013 (2013), Article ID 193018, 9 pages

Irshad, M.S., A.E. Yamamoto, T.E. Eneji and T. Honna, (2002). Urea and manure affect on growth anmineral contents of maize under saline conditions. *Journal of Plant Nutrition*. 25(1): 189-200.

Jackson, M.L., (1958). Soil Chemical Analysis. Prenstice-Hall, Inc., Engle Wood Cliffs. New Jersey. 183-204p.

Jama, B., C.A. Palm, R.J. Buresh, A. Niang, C. Gachengo, G. Nziguheba, and B. Amadalo, (2000). Tithonia diversifoliaas a green manure for soil fertility improvement in western Kenya: A review. Agroforestry Systems. 49: 201-221.

James, D.W., R.J. Hanks and J.J. Jurinak, (1982). Modern irrigated soils. John Willey and Sons, NewYork, NY 235 pp.

Jayne, M, Daniel M, James, K *and* Monicah-mucheru, M *(2008),* maize yields response to application of organic and inorganic input under on-station and on-farm experiments in central Kenya, *Nairobi, Kenya*

Johannes, B., (2000).The use of composted organic waste in viticulture – A review of the international literature and experience, Environment Australia, Canberra Sustainable Industries Branch.

Kenedy Tesfaye. (2004). *Field comparison of resource utilization and productivity of three grain species under water stress*. PhD.Thesis. Bloemfontein, Republic of South Africa. pp.234

Kihanda, F.M. and M. Gichuru, (1999). Manure management for soil fertility improvement. TSBF/AHI Report

Kimetu, J. M., Mugendi, D. N., Palm, C. A., Mutuo, P. K., Gachengo, C. N., Bationo, A., Nandwa, S., and Kungu, J. (2004). Nitrogen fertilizer equivalencies by organics of differing quantity and optimumcombinations with organic nitrogen source in central Kenya. *Nutrient Cycling in Agroecosystems* 68:127–135.

Kowalenko, C.G.,(1985): A modified apparatus for quick and versatile sulphate sulfur analysis using hydriodic acid reduction, Commun, Soilo Sci. Plant Anal.

Kumwenda, J.T., S.R. Waddington, S.S. Snapp, R.B. Jones and M.J. Blackie, (1996). Soil fertility management research for the maize cropping systems of smallholders in southern Africa: A review. Natural Resources Group Paper 96-02. Mexico City: International Maize and Wheat Improvement Center.

Lekasi, J.K.,(2000). Manure management in the Kenya highlands: collection, storage and composting strategies to enhance fertiliser quality. PhD Thesis. Coventry University, UK.

Lemcoff JH, Loomis RS. 1994. Nitrogen and density influences on silk emergence, endosperm development, and grain yield of maize (*Zea mays* L.). Journal of Field Crops Research 38(1), 63-72.

Maatman A, Wopereis MCS, Debrah KS, Groot JJR (2007). From Thousands to millions: Accelerating agricultural intensification and economic growth in Sub-Saharan Africa.

In: Bationo A, Waswa B, Kihara J, Kimetu J (eds). Advances in integrated soil fertility management in Sub-Saharan Africa: Challenges and opportunities, Springer, The Netherlands, pp. 75-84.

Makinde, E.A, (2007). Effects of an Organo–Mineral Fertilizer Application on the Growth and Yieldof Maize. *Journal of Applied Sciences Research.* 3(10): 1152-1155.

Maena , PP and CB Barrett.(2007). "State-conditional fertilizer yield response on western Kenya farm," Working Paper, Department of Applied Economics and Management, Cornell University, Ithaca

Marinari, S., G. Masciandaro, B. Ceccanti and S. Grego, 2000. Influence of organic and mineral fertilisers on soil biological and physical properties. Bio-resource Technology. 72: 9-17.

Mehta, Y. K. and M.S. Shaktawat,(2002). Response of maize to various sulphur, phosphorus andFYMlevels. Extended summaries In Second International Agronomy Congress on Balancing Foodand Environmental Security – A Continuing Challenge. Vol. 1, 26 - 30, November, NewDelhi, pp. 200 – 201

Mugendi, D. N., Nair, P. K. R., Mugwe, J. N., O'Neill, M. K. and Woomer, P. (1999). Alley cropping of maize with calliandra and leucaena in the subhumid highlands of Kenya. Part 1: Soil fertility changes and maize yield. *Agroforestry Systems* 46:39–50.

Muhammad, R., A. Hakoomat and M. Tariq, 2004. Impact of nitrogen and sulfur application on growth and yield of maize (*Zea mays* L.) crop. *Journal of Research (Science).*

Murphy, H.F., (2007). A report of on fertility status and other data on some soils of Ethiopia. Collage of Agriculture HSIU. Experimental station Bulletin No.44, Collage of Agriculture: 551P.

Muhammad, T., Asif T., Asghar A., Muhammad A. and Allah W. (2008), Comparative Yield Performance of Different Maize (*Zea mays* L.) Hybrids under Local Conditions of Faisalabad-Pakistan. Pak. j. life soc. 6(2): 118-120.

Nancy, M.T. and E.K. Marianne, (1997). Composting in theClassroomScientific Inquiryfor High School Students.

Nature (2012), Comparing the yields of organic and conventional agriculture, International weekely Jornal of science, 485 (229-232)

Nziguheba G, Merckx R, Palm CA, Rao M (2000). Organic residues effect phosphorus availability and maize yields in a Nitosol of Western Kenya. Biol. Fertil. Soils., 32: 328-339.

Nziguheba G (2007). Overcoming phosphorus deficiency in soils of Eastern Africa: recent advances and challenges. In: Bationo A, Waswa B, Kihara J, Kimetu J (eds).

Advances in integrated soil fertility management in Sub-Saharan Africa: Challenges and opportunities, Springer, The Netherlands, pp. 149-160.

Olsen, S.R., C.V. Cole, F.S. Watanab and L.A. Dean,(1954). Estimation of available phosphorous in soils by extraction with sodium bicarbonate. USA Circular. 939: 1-19.

Onasanya, R.O., Aiyelari, O.P., Onasanya, A., Nwilene, F.E. and Oyelakin, O.O. (2009), Effect of Different Levels of Nitrogen and Phosphorus Fertilizers on the Growth and Yield of Maize (*Zea mays* L.) in Southwest Nigeria. *International Journal of Agricultural Research, 4: 193-203.*

Onwueme, I.C. and T.D. Sinha, (1991). Field crop production in tropical Africa, CTA, Ede,and the Netherlands Publishing.

Palm, C. A., Myers, R. J. K. and Nandwa, S. M. (1997). Organic-inorganic nutrient interactions in soil fertility replenishment. In *Replenishing Soil Fertility in Africa*, 193–217 (Eds R. J. Buresh, P. A. Sanchez and F. Calhoun). Soil Science Society of America Special Publication 51: Soil Science Society of America, Madison WI, USA.

Parikh, S.J. & B.R. James, (2012). Soil: The foundation of Agriculture. Nature Education Knowledge 3(10) :2

Popkin, R.,(1995). Good news for waste watchers: recycling, composting show results for the future. *Environmental Protection Agency Journal*. 21: 188–90.

Quansah, G.L, (2010), effect of organic and inorganic fertilizers and their combinations on the growth and yield of maize in the semi-deciduous forest zone of Ghana

Rafique, M., A. Hussain, T. Mahmood, A.W. Alvi and M.B. Alvi. (2004). Heritability and interrelationships among grain yield and yield components in maize (*Zea mays* L.). Int'l. J. Agric. & Biol. 6(6): 1113-1114.

Rajeshwari, R., (2005). Integrated nitrogen management on growth and yield of maize (*Zea mays* L.)Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad - 580 005

Randhawa, P.S. and C.L. Arora, (2000). Phosphorus-sulfur interaction effects on dry matter yield and nutrient uptake by wheat. *Journal of Indian Society for SoilScience.* 48: 536–544.

Sarwar, G., H. Schmeisky, M.A. Tahir, Y. Iftikhar and N.U. Sabah, (2010).application of greencompost for improvement in soil chemical properties and fertility status. *The Journal of Animal andPlant Sciences,* 20(4):258-260.

Sahlemedhin Serstu and Taye Bekele, (2000). Procedure for soil and plant analysis. National Soil Research Centre, Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia.

Sanchez, P.A. and B.A. Jama, (2002). Soil fertility replenishment takes off in East and Southern 9Africa. In: Integrated Plant Nutrient Management in sub-Saharan Africa:From concept to practice. B. Vanlauwe, J. Diels, N. Sanginga and R. Merckx (Eds.). CAB Int., Wallingford, UK. pp. 23-45.

Saranappa, 2002. Integrated nutrient supply for enhancing crop productivity and sustaining soil fertility. Extended summaries. In Second International Agronomy Congress on Balancing Food and Environmental Security – A continuing Challenge. Vol. 1, 26 - 30, November, New Delhi, pp. 335 - 336.

Sarhad J. (2011), correlations among grain yield and yield attributes in maize hybrids at various nitrogen levels. *Jornal of Agric. Vol.27, No.4,*

Schlecht, E., A. Buerkert, E. Tielkes and A. Bationo, 2006. A critical analysis of challenges and opportunities for soil fertility restoration in Sudano-Sahelian West Africa, Nutrient Cycling In Agroecosystems. 76: 109-136.

Schlegel, A.J., 1992. Effect of composted manure on soil chemical properties and nitrogen use by grain sorghum. *Journal Product of Agriculture*. 5:153-157.

Shahidur, R., Kindie Getinet and Solomon Lemma, (2010). Maize value potential chain in Ethiopia, constraints and opportunities forenhancing the system.

Singer, J.W., K.A. Kohler, M. Liebman, T.L. Richard, C.A. Cambardella and D.D. Buhler, 2004. Integrated agricultural systems. Tillage and Compost Affect Yield of Corn, Soybean, and Wheat, Soil Fertility. *American Society of Agronomy*. 56: 235-239.

Sylvia, M.D., J.J. Fuhrmann, P.G. Hartel and D.A. Zuberer, 1999. Principles and applications of soils microbiology. Printice Hall Inc. Upper Saddle River. New Jersey, USA 550 pp.

Tasnee, A. and R.S. Yost, (2003). A site-specific nutrient management approach for maize, better crops international vol. 17, no. 1.

Tayebeh Abedi, Abass Alemzadeh and Seyed Abdolreza Kazemeini, (2010). Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat, Department of Crop Production and Plant Breeding, School of Agriculture, Shiraz University, Shiraz, Iran, Australian journal of crop science, pp385-387.

Tekalign Tadesse. (1991). Soil, plant, water, fertilizer, animal manure and compost analysis. Working document No.13. International live stock research center for Africa, Adis Abeba.

Thomas, J.H., (2004). Effects of composted dairy manure on soil chemical properties and forage yield and nutritive value of coastal bermudagrass (*Cynodon dactylon (L.) Pers.).*

Tiquia, S.M. and N.Y. Tam, (2002). Characterization and composting of poultry litter in forced- aeration piles, Process Biochemistry. 37, 869– 880.

Wakene Negassa, Fite Getaneh, Abdena Deressa, and Berhanu Dinsa, (2007).Integrated use of organic and inorganic Fertilizers for maize production, University of Rostock, Institute of Land Use, Justus- von-Liebig Weg 6, 18059, Rostock, Germany.

Wakene Negassa, Kefyalew Negisho, D.K. Friesen, J. Ransom and Abebe Yadesa, (2001). Determination of optimum farmyard manure and NP fertilizers for maize on farmer's fields, seventh Eastern and Southern Africa regional maize conference pp 387-393.

Walkley, A. and C.A. Black, (1934). An examination of different methods for determining soil organic matter and the proposed modification by the chromic acid titration method.

World Fact book (2016). *Ethiopia Country Profile.* Retrieved July 15, 2016, from http://bit.ly/1yAYHLA

Zarina, B., N. Ullah, K. Mmuh, A. Akram, Q.U. Khan, M.J. Khan, S. Batool and K. Makhdoom, (2010). Maize response to integrated use of NP-fertilizers and compost, Department of Soil and Environmental Sciences, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Pakistan. *Pakistan Journal of Botany*. 42(4): 2793-2801

Zougmoré, R.,(2003). Integrated water and nutrient management for sorghum production in semi-arid Burkina Faso.Tropical Resource Management papers, N° 45, WageningenUniversity, Wageningen, The Netherlands. 205 pp.

7. APPENDIX

Appendix Table 1. Detail of partial budget analysis

Treat.	Labor cost for frt. Application			Input price ET bir.			Total cost	Yield t/ha		In come ETbr		Gross	Net
	urea	D/NPKSB	compost	urea	D/NPKSP	compost		grain	strow	grain	strow	bnfit	ben
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.87	13.07	30915.00	5228.00	36143.0	36143.00
2	300.00	400.00	0	2034.70	1336.93	0	4071.63	8.22	14.15	36990.00	5660.00	42650.0	38578.37
3	300.00	400.00	0	2034.70	2673.86	0	5408.56	8.81	14.99	39645.00	5996.00	45641.0	40232.44
4	300.00	400.00	0	2034.70	3743.40	0	6478.10	8.93	14.96	40185.00	5984.00	46169.0	39690.90
5	300.00	400.00	0	2034.70	2736.32	0	5471.02	8.93	16.15	40185.00	6460.00	46645.0	41173.98
6	0.00	0.00	500.00	0.00	0.00	1818.00	2318.00	7.59	14.98	34155.00	5992.00	40147.0	37829.00
7	300.00	400.00	500.00	2034.70	1336.93	1818.00	6389.63	8.81	14.68	39645.00	5872.00	45517.0	39127.37
8	300.00	400.00	500.00	2034.70	2673.86	1818.00	7726.56	9.04	15.07	40680.00	6028.00	46708.0	38981.44
9	300.00	400.00	500.00	2034.70	3743.40	1818.00	8796.10	9.02	15.45	40590.00	5780.00	46370.0	37573.90
10	300.00	400.00	500.00	2034.70	2736.32	1818.00	7789.02	9.21	15.57	41445.00	6228.00	47673.0	39883.98
11			1000.00	0	0	3636.00	4636.00	8.21	15.17	36945.00	6068.00	43013	38377.00
12	300.00	400.00	1000.00	2034.70	1336.93	3636.00	8707.63	9.13	15.83	41085.00	6332.00	47417.0	38709.37
13	300.00	400.00	1000.00	2034.70	2673.86	3636.00	10044.56	9.08	15.05	40860.00	6020.00	46880.0	36835.44
14	300.00	400.00	1000.00	2034.70	3743.4	3636.00	11114.10	9.45	15.08	42525.00	6032.00	48557.0	37442.90
15	300.00	400.00	1000.00	2034.70	2736.32	3636.00	10107.02	9.56	15.20	43020.00	6080.00	49100.0	38992.98

Appendix Table 2.Detail of partial budget analyses

Tr no	Labor cost for frt. Application			Input price ET bir.			Total cost	Yield t/ha		In come ETbr		Gross bnfit	Net ben	MRR %
	UREA	NPKSB/D	compost	urea	NPKSB/D	compost		grain	strow	grain	strow			
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.87	13.07	30915.00	5228.00	36143.0	36143.00	-
6	0.00	0.00	800.00	0.00	0.00	1818.0	2618.00	7.59	14.98	34155.00	5992.00	40147.0	37829.00	72.74
2	300.00	400.00	0	2034.70	1336.93	0	4071.63	8.22	14.15	36990.00	5660.00	42650.0	38578.37	42.73
11	0.00	0.00	1000.00	0	0	3636.00	5236.00	8.21	15.17	36945.00	6068.00	43013.0	38377.00	D
3	300.00	400.00	0	2034.70	2673.86	0	5408.56	8.81	14.99	39645.00	5996.00	45641.0	40232.44	123.72
5	300.00	400.00	0	2034.70	2736.32	0	5471.02	8.93	16.15	40185.00	6460.00	46645.0	41173.98	1507.43
7	300.00	400.00	500.00	2034.70	1336.93	18.18.0	6389.63	8.81	14.68	39645.00	5872.00	45517.0	39127.37	D
4	300.00	400.00	0	2034.70	3743.40	0	6478.10	8.93	14.96	40185.00	5984.00	46169.0	39690.90	D
8	300.00	400.00	500.00	2034.70	2673.86	1818.00	7726.56	9.04	15.07	40680.00	6028.00	46708.0	38981.44	D
10	300.00	400.00	500.00	2034.70	2736.32	1818.00	7789.02	9.21	15.57	41445.00	6228.00	47673.0	39883.98	D
12	300.00	400.00	1000.00	2034.70	1336.93	3636.00	8707.63	9.13	15.83	41085.00	6332.00	47417.0	38709.37	D
9	300.00	400.00	500.00	2034.70	3743.40	1818.00	8796.10	9.02	15.45	40590.00	5780.00	46370.0	37573.90	D
13	300.00	400.00	1000.00	2034.70	2673.86	3636.00	10044.56	9.08	15.05	40860.00	6020.00	46880.0	36835.44	D
15	300.00	400.00	1000.00	2034.70	2736.32	3636.00	10107.02	9.56	15.20	43020.00	6080.00	49100.0	38992.98	D
14	300.00	400.00	1000.00	2034.70	3743.4	3636.00	11114.10	9.45	15.08	42525.00	6032.00	48557.0	37442.90	D

Appendix Table 3.Sensitivity analysis with 10% cost increment and 10% gross benefit decrement

Treatment	Cost	Cost 10% increment	**G/benefit**	G/benefit 10 % discount	**Net benefit**	MRR%
1	0.00	0.00	36143.00	32528.70	32528.70	
6	2318.00	2549.80	40147.00	36132.30	33582.50	41.33
2	4071.63	4478.79	42650.00	38385.00	33906.21	16.78
11	4636.00	5099.60	43013.00	38711.70	33612.10	D
3	5408.56	5949.42	45641.00	41076.90	35127.48	83.04
5	5471.02	6018.12	46645.00	41980.50	35962.38	1215.28
7	6389.63	7028.59	45517.00	40965.30	33936.71	D
4	6478.10	7125.91	46169.00	41552.10	34426.19	D
8	7726.56	8499.22	46708.00	42037.20	33537.98	D
10	7789.02	8567.92	47673.00	42905.70	34337.78	D
12	8707.63	9578.39	47417.00	42675.30	33096.91	D
9	8796.10	9675.71	46370.00	41733.00	32057.29	D
13	10044.56	11049.02	46680.00	42012.00	30962.98	D
15	10107.02	11117.72	49100.00	44190.00	33072.28	D
14	1114.10	12225.51	48557.00	43701.30	31475.79	D